Fostering analytic metacognitive processes and reducing overconfidence by disfluency: The role of contrast-effects

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Abstract

Overconfidence leads to premature termination of study and, thus, to decreased performance. The aim of the present study is to improve students´ monitoring and control. We assume that disfluency fosters analytic metacognitive processes and thus reduces overconfidence. However, we expect that contrast-effects moderate the fluency-effects on metacognitive processes because disfluency activates analytic metacognitive processes not only for disfluent but also for succeeding fluent learning material. To test our hypotheses, university students (N = 75) learned either with a fluent text first and afterwards a disfluent text or with a disfluent text first and afterwards a fluent text. The results show fluency-effects on control, monitoring, and monitoring accuracy only when students learned with a fluent and afterwards a disfluent text. Performance was worse for disfluent than for fluent texts in both conditions. Therefore, instructional settings that help students to implement accurate monitoring into better control and better performance are required.

Keywords: metacomprehension; disfluency; overconfidence; monitoring; control

1. Introduction

Students are often disappointed about their performance in an exam because they had expected better grades than they received. They usually have to learn from textbooks to prepare for an exam. Therefore, they have to monitor whether they understand the concepts (*metacomprehension*, Maki & Berry, 1984) and decide how much time and effort to invest. However, students are often *overconfident* and thus judge the material as too easy (Authors, 2016) and their performance as too high compared with their actual grades (e.g., Baker, Dunlosky, & Hertzog, 2010; Dunlosky, Hartwig, Rawson, & Lipko, 2011; Miesner & Maki, 2007). This phenomenon is observed in educational contexts and is also called the *illusion of knowing* (Glenberg, Wilkinson, & Epstein, 1982; see also Pieschl, 2009, for other terms). However, accurate monitoring of one´s own learning process is important to adequately control one´s own learning and, thus, to improve performance (Thiede, Anderson, & Therriault, 2003). This is supposed by several theories of metacognition and self-regulated learning (e.g., Boekaerts, 1997; Nelson & Narens, 1990; Winne & Hadwin, 1998; Zimmerman, 1990). If students are overconfident, performance suffers (Dunlosky & Rawson, 2012) because students do not invest enough time and effort for their learning. Thus, one aim of our study is to investigate how metacognitive processes can be improved and how overconfidence can be reduced. Therefore, the relationship between metacognitive processes and performance is considered.

In this study, we investigate whether *disfluency* (reduced ease of processing) is a way to improve monitoring accuracy by reducing overconfidence. Moreover, we consider conditions for the *fluency-effects* (differences between fluent and disfluent material) on metacognitive monitoring, control, and performance. We assume that fluency-effects should only be found when students first learn with a fluent and afterwards a disfluent text because disfluency can activate analytic metacognitive processes that remain even for succeeding fluent material (Alter, Oppenheimer, Epley, & Eyre, 2007), which will be described in more detail in our theoretical framework.

1.1 The Role of Disfluency in Metacognitive Monitoring, Control, and Performance

Monitoring can be defined by the assessment of learning processes, whereas control means the regulation of these processes (Koriat, Ma'ayan, & Nussionson, 2006; Schwartz & Perfect, 2002). According to Koriat (2012), theories of self-regulated learning often imply a causal chain from monitoring to control and performance. However, monitoring not only affects control (*monitoring-based control*) but is also affected by control (*control-based monitoring*, see also Koriat et al., 2006). Moreover, the interplay between monitoring and control, and performance can be affected by disfluency, which will be described in the next sections.

1.1.1 Disfluency and control. In previous research, there is evidence for the fluency-effect on control: Studies have found longer reading- or study-times for disfluent compared with fluent texts (e.g., Eitel & Kühl, 2016; Miele & Molden, 2010, Experiment 3; Sanchez & Jaeger, 2015, Experiment 1 and 2). In these studies, fluency was manipulated by font type, which is a common manipulation of processing fluency (Alter & Oppenheimer, 2009). This type of fluency affects surface text characteristics but not the text content itself. Because a disfluent font type is difficult to decipher, students control their learning by slowing down reading. Thus, longer reading-times can be explained by slower, less automatic processing due to difficulties in deciphering the words (and not due to difficulties in understanding the text).

Disfluency does not only lead to less automatic processing, but it is further supposed to lead to more effortful processing than fluency (e.g., Eitel, Kühl, Scheiter, & Gerjets, 2014, Experiment 1). To test whether disfluency leads to more effortful processes, measurement should not be limited to time for reading or rereading. A preferred measure of students` invested cognitive resources during learning is subjective ratings (see Rey & Nieding, 2010;

Schmeck, Opfermann, Van Gog, Paas, & Leutner, 2015). Perceived difficulty and mental effort are widely used (Schmeck et al., 2015) because these measures capture different aspects of learning (Van Gog & Paas, 2008): Whereas the first mainly refers to the task and its perceived difficulty, the latter considers whether students further invest mental effort during learning (e.g., although the task is difficult). In previous research, there is some evidence that students report higher perceived difficulty (Miele & Molden, 2010, Experiment 3; Sanchez & Jaeger, 2015, Experiment 1 and 2; Song & Schwarz, 2008b, Experiment 1, 2, and 3) and higher invested mental effort (e.g., Eitel, et al., 2014, Experiment 1) for disfluent than for fluent texts. However, evidence is not that straightforward because there are also studies that did not find these fluency-effects on perceived difficulty (e.g., Eitel & Kühl, 2016; Eitel et al., 2014, Experiment 1-4) and mental effort (e.g., Eitel & Kühl, 2016; Eitel et al., 2014, Experiment 2–4).

Aside from the partial evidence that disfluency leads to effortful processes, there is also partial evidence that disfluency further activates analytic processes (Alter et al., 2007). In their Experiment 2, Alter et al. (2007) presented arguments in a fluent font and manipulated only the fluency of the masthead. They found more analytic and more deliberate processing of the (fluently presented) arguments in persuasion, when (only) the masthead was printed in a disfluent font. They supposed that disfluency was a metacognitive cue that activated analytic processes. Although there are some findings that are in accordance with this assumption (e.g., Song & Schwarz, 2008a, Experiment 1 and 2), evidence is not conclusive (see Kühl & Eitel, 2016; Meyer et al., 2015, for an overview of different materials and tasks) and thus, further research is required.

Summing up, disfluent text is difficult to process (i.e. deciphering words). Therefore, disfluency should affect student´s control-processes during reading a disfluent text.

1.1.2 Disfluency and monitoring. Because disfluency affects control (e.g., by less automatic processing) and control affects monitoring (control-based monitoring), disfluency should affect metacognitive judgments, which are often used to measure monitoring. During the learning process, students can make different types of metacognitive judgments, which judgments refer to different aspects of monitoring (Nelson & Narens, 1990). Previous research has focused on learning with word-pairs, where students are usually asked to predict their performance (*judgment of learning*). There is evidence that students predict lower performance for disfluent compared with fluent word-pairs (e.g., Magreehan, Serra, Schwartz, & Narciss, 2016, Experiment 4 and 5; Mueller, Tauber, & Dunlosky, 2013, Experiment 2) and words or word-lists (Besken & Mulligan, 2013; Kornell, Rhodes, Castel, & Tauber, 2011; Yue, Castel, & Bjork, 2013, Experiment 1a, 2a, 2b, and 3). However, learning with texts is more complex compared to learning with word-pairs, words or word-lists. When learning with texts, students have not only to decipher words (*surface level*). In order to comprehend the text, they have to build sense within and between words and sentences (*textbase-level)*. Finally the content and its meaning has to be integrated into the memory (*situation model*; Kintsch, 1994; see also Redford, Thiede, Wiley, & Griffin, 2012). To monitor the different levels of text-processing, students should make different types of judgments at different learning stages.

At early learning stages, when reading a text for the first time, students might first focus on deciphering the words, especially if words are presented in a disfluent font type. Because fluency affects the ease of deciphering the words, it should affect the *ease of learning judgments*. Supporting this assumption, students predict that disfluent texts will be more difficult to learn than fluent texts (Authors, 2016). These ease of learning judgments have often been neglected in previous research (Jönsson & Lindström, 2010), but they can affect the further learning process (e.g., Nelson & Leonesio, 1988) and are thus important when rereading a text. This also applies to *familiarity judgments* that are also rarely considered, although domain familiarity with a topic can inform further learning as well as judgments of learning (Shanks & Serra, 2014). The feeling that a text is easy to read should lead to the feeling that the topic is familiar. Thus, disfluency should affect familiarity judgments (see also Westerman, Lanska, & Olds, 2015).

Having deciphered the words (surface level) after reading a text once, students should reread the text to comprehend it (text-base level) and memorize it (situation model). To monitor their actual comprehension, students can make *comprehension judgments*. Dependent from the specific question of the comprehension judgment, the specific task, or the timing, these judgments could refer to different levels of text-processing (e.g., delayed comprehension judgments might refer to the situation model). However, when students judge how difficult it was to understand the text immediately after learning the text, comprehension judgments should mainly refer to the text-base level of text-processing. Although disfluency does not affect the difficulty of the text content, there is evidence that students judge disfluent compared with fluent texts as more difficult to comprehend (Maki, Foley, Kajer, Thompson, & Willert, 1990, Experiment 1; Miele & Molden, 2010, Experiment 3; Rawson & Dunlosky, 2002, Experiment 4). Thus, comprehension judgments are affected by the experience of difficulty in processing (i.e., deciphering the words). This experience can also affect judgments of learning (Authors, 2016). These judgments ask students about their prospective performance in a test. Thus, they should mainly refer to the situation model of text-processing. This is supported by the finding by Maki et al. (1990, Experiment 1) that students used retrieval as an additional cue besides fluency for judgments of learning, whereas retrieval was not used for comprehension judgments. Nevertheless, both types of judgments can be affected by disfluency (e.g., Rawson & Dunlosky, 2002, Experiment 4) and thus, disfluency can affect different types of judgments that refer to higher levels of text-processing.

That different types of judgments capture different aspects of monitoring is also supported by findings by Leonesio and Nelson (1990). They found that ease of learning judgments and judgments of learning are only weakly correlated. Ease of learning judgments and judgments of learning are *prospective judgments*. However, students can further make *retrospective judgments*. These judgments usually ask students about their confidence in a retrieved answer (*retrospective confidence judgments*, see also Nelson & Narens, 1990). Dinsmore and Parkinson (2013) found that students often use text characteristics as cues for these judgments. Thus, using disfluency as a text characteristic, students should make lower retrospective confidence judgments for disfluent than for fluent texts.

In sum, because disfluency compared to fluency leads to less automatic processes, students should judge their comprehension and their performance as lower. As a consequence overconfidence should be reduced. Inversely, fluency induces illusions of knowing because students experience ease of processing. This experience of ease of processing leads to the feeling that the text has been understood and that the content can be retrieved, even though fluency does not necessarily affect performance, which is described next.

1.1.3 Disfluency and performance - Inconsistent empirical evidence and the role of metacognitive processes. Evidence regarding fluency-effects on performance is inconsistent (see Kühl & Eitel, 2016, for an overview). Findings of better performance for disfluent than for fluent material (e.g., Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Eitel et al., 2014, Experiment 1) support the assumption that disfluency leads to deep, analytic, and effortful processes (Alter et al., 2007; see also section 1.1.1). Inversely, findings that disfluency does not affect performance (e.g., Eitel et al., 2014, Experiment 2–4; Rummer, Schweppe, & Schwede, 2016; Strukelj, Scheiter, Nyström, & Holmqvist, 2016) as well as findings of lower performance for disfluent than for fluent material (e.g., Miele & Molden, 2010, Experiment 3, for text; Mueller et al., 2013, Experiment 2, for word-pairs; Yue et al., 2013, Experiment 1a and 2a, for word-lists) contradict the assumption that disfluency activates deep, analytic, and effortful processes. Because of these inconsistent findings, some studies have investigated conditions for the fluency-effect on performance (see Kühl & Eitel, 2016, for an overview). This is important in order to derive implications for educational settings (e.g., Bjork & Yue, 2016). However, research is still far from able to predict fluency-effects on performance.

We assume that fluency-effects on monitoring and control are necessary in order to find fluency-effects on performance: Theories of metacognition and self-regulated learning suppose that monitoring affects control (monitoring-based control, see above) and thus affects performance. Regarding monitoring-based control, there is evidence that judgments affect control-processes (e.g., Nelson & Leonesio, 1988; Thiede & Dunlosky, 1999; see Son & Kornell, 2008, for an overview). Moreover, the discrepancy-reduction model (see Dunlosky & Metcalfe, 2009, for an overview) supposes that students learn material longer when they judge it as more difficult to learn. When reading a disfluent text, students predict that this disfluent text will be more difficult to learn than a fluent text. Basing control on these judgments, students should reread disfluent compared with fluent text longer, and they should further invest greater effort when rereading the disfluent text. Hence, fluency-effects on metacognitive monitoring and control might be a presupposition for fluency-effects on performance: Better performance can only be expected if disfluency improves monitoring and if monitoring is used to control learning.

However, although metacognitive processes might be a presupposition for fluency-effects on performance (e.g., Alter et al., 2007), fluency-effects on metacognitive processes during the learning process are rarely investigated in more detail (e.g., Authors, 2016). Moreover, there are very little studies about conditions for the fluency-effect on judgments (e.g., Magreehan et al., 2016, for word-pairs; Susser, Mulligan, & Besken, 2013, for word-lists), especially using texts as learning material. This is the case, although there are some studies that did not find fluency-effects on judgments when learning with word-pairs (e.g., Magreehan et al., 2016, Experiment 1, 2, and 3) with word-lists (e.g., Sungkhasettee, Friedman, & Castel, 2011, Experiment 1 and 2; Yue et al., 2013, Experiment 1b) or with texts (Maki et al., 1990, Experiment 2; McDaniel, Einstein, Dunay, & Cobb, 1986). Thus, the aim of our study is to investigate conditions for the fluency-effects on metacognitive processes and, thus, on performance.

1.1.4 Analytic metacognitive processes and type of contrast in fluency. Disfluency can affect different types of metacognitive judgments during the learning process (see section 1.1.2). These judgments can be used to control further learning, e.g., when rereading the text and deciding how much time and effort to invest (see section1.1.3). After rereading, students can use not only disfluency as a cue for judgments but also the difficulty of the text content, which should be a more valid cue for performance. Analytic monitoring allows students to use cues that are valid for their performance and, thus, to improve judgment accuracy. Therefore, it is important to foster analytic monitoring when learning with texts. Alter et al. (2007) found that disfluency is a metacognitive cue that activates analytic processes. In their Experiment 2, students processed a short persuasive text in a more analytic and deliberate way when the masthead was disfluent than when it was fluent. This was the case even though only the masthead and not the texts themselves were disfluent. Thus, processing of succeeding texts was affected by the activation of analytic monitoring when reading the masthead.

Therefore, we conclude that fluency-effects on metacognitive processes should be found when fluent material is presented before disfluent material (we will call this *contrast fluent-disfluent*). In this case, the metacognitive processes for the fluent text should be more surface compared with more analytic metacognitive processes when learning with the succeeding disfluent text (see Figure 1a). Inversely, when students first learn with a disfluent and afterwards a fluent text (we will call this *contrast disfluent-fluent*), disfluency is a metacognitive cue that activates analytic monitoring and control. These analytic processes (instead of surface processes) should also be found for succeeding fluent material (see Figure 1b). This assumption is supported by the finding of increased reaction times for fluent tasks that succeed disfluent tasks compared with reaction times for fluent tasks that succeed fluent tasks (Dreisbach & Fischer, 2011). Because of more analytic processing, students focus on conceptual text cues (e.g., difficulty of the text content) when learning with the disfluent text and also when learning with the succeeding fluent text. Therefore, students should base their judgments on these conceptual cues instead of fluency cues for both texts. As a result no fluency-effect on judgments is expected for contrast disfluent-fluent.

Summing up, the *type of contrast* should affect the fluency-effect on monitoring and control and, thus, on metacognitive processes.

Insert Figure 1 here

1.2 Research Question and Hypotheses

The aim of our study is to foster analytic metacognitive processes and to improve monitoring accuracy for different types of judgments during the learning process. Moreover, we investigate under which conditions fluency-effects on metacognitive processes and on performance are found. We suppose that disfluency leads to less automatic, more analytic processes and thus reduces overconfidence. Because analytic metacognitive processes (activated by disfluency) remain for the succeeding learning material, we expect reduced fluency-effects for contrast disfluent-fluent compared with fluency-effects for contrast fluent-disfluent. In more detail, this *contrast hypothesis* should apply to all of the following hypotheses regarding the fluency-effect on control, monitoring, and performance:

1.2.1 Control hypothesis. Disfluent texts lead to less automatic and more analytic processing compared with fluent texts. Therefore, we expect longer reading-times for disfluent than for fluent texts. Moreover, when studying with disfluent compared with fluent texts, students should terminate their study later, perceive higher difficulty and invest higher mental effort.

1.2.2 Monitoring hypothesis. Students should make lower ease of learning judgments (Authors, 2016) and lower familiarity judgments after reading a disfluent compared with a fluent text. Moreover, students should make lower comprehension judgments (Maki et al., 1990) and lower judgments of learning (Authors, 2016) for disfluent compared with fluent texts. During the test, we further expect lower retrospective confidence judgments. Due to less automatic and more analytic processes during reading and rereading and due to lower judgment magnitudes, overconfidence should be reduced, and therefore, monitoring accuracy should be improved.

1.2.3 Performance hypothesis. Performance should be affected by monitoring and control-processes during reading and rereading the texts. Although deciphering the words should not affect performance, disfluency can improve performance by improved metacognitive processes. This is the case if students translate their judgments into higher effort and later termination of study.

2. Method

2.1 Participants and Design

Students (*N* = 75, age: *M* = 20.76, *SD* = 1.97, 80% female) from a university in Germany (semester of studies: *M* = 3.12, *SD* = 1.59) learned with two texts about social psychology. Students studied media communication (*N* = 55), human-computer interaction (*N* = 15), business economics (*N* = 2), teacher education (*N* = 2), and German philology (*N* = 1). The sample size of the study fulfills a required sample size of *N* = 75 students, computed with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). Because medium to high effect sizes were found for perceptual disfluency (e.g., Song & Schwarz, 2008b; Mueller et al., 2013; Yue et al., 2013), a Type I error of .05, a power of .80, and an effect size of *f* = .33 are assumed. For their participation, students either received credit points or took part in a lottery in which they could win one of two 25 € vouchers.

Students were randomly assigned to one of two groups. Students in *contrast group fluent-disfluent* (*N* = 37) learned with a fluent and afterwards a disfluent text, and students in *contrast group disfluent-fluent* (*N* = 38) learned with a disfluent and afterwards a fluent text. Thus, we used a 2 (fluency) x 2 (type of contrast) design to test the effect of fluency (within factor) and type of contrast (between factor) on control (reading-time, termination of study, perceived difficulty, and mental effort), on monitoring (judgments), on monitoring accuracy, and on performance.

2.2 Material

Fluency was varied by using Mistral (18 point) for disfluent texts and Times New Roman (16 point) for fluent texts. This fluency-manipulation has been found to affect judgments and control-processes in previous studies (e.g., Authors, 2016; Dreisbach & Fischer, 2011; Song & Schwarz, 2008b). Two texts from scientific textbooks about social psychology (Aronson, Akert, & Wilson, 2008; Kanning, 2002) served as learning material and were adapted for the current study in a way that enabled the students to read the texts without previous knowledge. Text A addressed the topic “attitudes” and consisted of 1,019 words (Flesch-Kincaid grade-level score = 19.69). Text B described social skills and consisted of 900 words (Flesch-Kincaid grade-level score = 21.71). Flesch-Kincaid grade-level scores of readability were computed using a tool from Michalke (2012), and both texts were classified as being of comparable difficulty and length.

2.3 Procedure and Instruments

To present the material and to capture the data, *E-Prime-Software* (E-Prime Professional 2.0) was used. The whole experiment took approximately 90 minutes. All judgments were answered on a continuous visual analogue scale by typing in integer numbers. The procedure is visualized in Figure 2.

Insert Figure 2 here

Students were instructed to read the first text once, and reading-time was captured as a manipulation-check. Immediately afterwards, students made an ease of learning judgment (“How easy or difficult is it to learn the text?”, continuous scale, labeled from 0 = *difficult* to 50 = *middle* to 100 = *easy*) and a familiarity judgment (“How familiar are you with the topic of the text?”, continuous scale, labeled from 0 = *not familiar* to 50 = *middle* to 100 = *familiar*). Then, students reread the text for a maximum of 15 min. They were allowed to terminate their study before the time elapsed and to take notes. Afterwards, they made a comprehension judgment (“How easy was it to understand the text?”, continuous scale, labeled from 0 = *difficult* to 50 = *middle* to 100 = *easy*) and a judgment of learning (“What percentage of questions about the text will you answer correctly?”, continuous scale, labeled from 0 = *none* to 50 = *half* to 100 = *all*). To capture more than objective measures for control-processes such as termination of study, we further captured subjective measures for control (see also Paas, 1992; Rey & Nieding, 2010; Schmeck et al., 2015; Van Gog & Paas, 2008): Students reported their perceived difficulty during rereading (“How difficult was it to learn the text?”, continuous scale, labeled from 0 = *difficult* to 50 = *middle* to 100 = *easy*) and their invested mental effort (“How much mental effort did you invest during learning?”, continuous scale, labeled from 0 = *none* to 50 = *middle* to 100 = *high*). Afterwards, the same procedure was repeated with the second text (text order was randomized). In contrast group fluent-disfluent, the second text was disfluent, whereas in contrast group disfluent-fluent, the second text was fluent. Finally, the students filled in a knowledge test with 31 questions on each text. In the first question, students were asked to write down as many technical terms as they remembered (retention question). For each of the remaining 30 questions (knowledge questions), 6 statements were presented on one screen and students had to keyboard which statements were true. Students were informed that anywhere from none to all statements of a question could be true. Students received one point for each statement of a question they correctly identified as true or false. After each question, a retrospective confidence judgment

("How confident are you that your answer is correct?", continuous scale, labeled from 0 = *unconfident* to 50 = *middle* to 100 = *confident*) had to be answered. The sequence of questions on the text corresponded to the sequence of text presentation. The reliability of the test was Cronbach´s α = .86 (*M* = 53.24, *SD* = 10.40).

3. Results

Data were analyzed using *IBM SPSS 23*, and the Type I error was set to .05 for all analyses. Performance of knowledge questions was computed as the mean of all statements, and this mean was corrected for guessing using the 200·x – 100 algorithm. The reason is that for each question, 6 statements were presented, and each statement could be answered as correct or not (see section 2.3). Thus, there is a 50% chance of correctly guessing the answer for each statement and, consequently, for the mean of all statements. The algorithm transforms the value of guessing (50%) to zero (200·0.50 – 100 = 0), resulting in a metric from 0% to 100% that is comparable to the metric of the judgments (see also Authors, 2016). Monitoring accuracy was computed by subtracting corrected performance from judgment magnitudes. Negative values indicate underconfidence, positive values indicate overconfidence, and values close to zero indicate perfect absolute monitoring accuracy (Authors, 2010).

Descriptive statistics of dependent variables (monitoring, control, and performance) can be found in Table 1. We computed a mixed MANOVA to test our hypothesis that the type of contrast affects fluency-effects on dependent variables (correlations between dependent variables can be found in Appendix A, Table A1). We used type of contrast (fluent-disfluent vs. disfluent-fluent) as a between-subject factor and fluency (fluent vs. disfluent) as a within-subject factor. Monitoring (ease of learning judgment, familiarity judgment, comprehension judgment, judgment of learning, and retrospective confidence judgment), control (reading-time, termination of study, perceived difficulty, and mental effort), and performance (retention and knowledge questions) were used as dependent variables. Because monitoring accuracy is calculated from monitoring and performance of knowledge questions, monitoring accuracy is not included into the mixed MANOVA. The results showed a significant multivariate main effect of fluency, $V = .651$, $F(11, 60) = 10.18$, $p < .001$, $\eta_p^2 = 0.65$, and a significant interaction between fluency and type of contrast, $V = .313$, $F(11, 60) = 2.48$, $p = .012$, $\eta_p^2 = 0.31$. The main effect of type of contrast was not significant, $V = .149$, $F(11, 60) = 0.96$, $p = .496$, $\eta_p^2 = 0.15$. These significant effects are analyzed in more detail in the next sections.

Insert Table 1 here

3.1 Control

Regarding control, the following univariate analyses showed a significant main effect of fluency on reading-time: Students read disfluent texts significantly longer than fluent texts, $F(1, 73) = 67.33$, $p < .001$, $\eta_p^2 = .48$, and thus, our manipulation was successful. This was the case in contrast group fluent-disfluent and in contrast group disfluent-fluent, as no significant interaction between fluency and type of contrast was found, $F(1, 73) = 0.14$, $p = .709$, $\eta_p^2 < 0.01$. For termination of study, neither a significant interaction between fluency and type of contrast, $F(1, 73) = 0.06$, $p = .814$, $\eta_p^2 < 0.01$, nor a significant main effect of fluency, $F(1, 73) = 0.18$, $p = .675$, $\eta_p^2 < 0.01$, was found. However, we found a significant interaction between fluency and type of contrast for perceived difficulty, $F(1, 73) = 14.78$, $p < .001$, $\eta_p^2 = 0.17$, and for mental effort, $F(1, 72) = 4.14$, $p = .046$, $\eta_p^2 = 0.05$. Students in contrast group fluent-disfluent reported that the disfluent text was more difficult to learn than the fluent text, $F(1, 36) = 31.21$, $p < .001$, $\eta_p^2 = 0.46$, and they reported that they invested higher mental effort in the disfluent than in the fluent text, $F(1, 36) = 9.97$, $p = .003$, $\eta_p^2 = 0.22$. In contrast group disfluent-fluent, no significant difference for perceived difficulty, $F(1, 37) = 0.01$, $p = .935$, $\eta_p^2 < .01$, or for mental effort, $F(1, 36) = 0.94$, $p = .339$, $\eta_p^2 = 0.03$, was found.

3.2 Monitoring

Concerning judgment magnitudes, the univariate analyses revealed a significant interaction between fluency and type of contrast for ease of learning judgments, $F(1, 71) = 16.27$, $p < .001$, $\eta_p^2 = 0.19$, for familiarity judgments, $F(1, 72) = 4.45$, $p = .038$, $\eta_p^2 = 0.06$, for comprehension judgments, $F(1, 73) = 19.01$, $p < .001$, $\eta_p^2 = 0.21$, and for judgments of learning, $F(1, 73) = 13.56$, $p < .001$, $\eta_p^2 = 0.16$. These results support our hypothesis that the fluency-effect on judgments depends on the type of contrast. This is because only students in contrast group fluent-disfluent judged that disfluent texts compared to fluent texts would be more difficult to learn (ease of learning judgment), $F(1, 34) = 15.87$, $p < .001$, $\eta_p^2 = 0.32$ and that the disfluent text was less familiar (familiarity judgment), $F(1, 35) = 5.75$, $p = .022$, $\eta_p^2 = 0.14$ and more difficult to understand (comprehension judgment), $F(1, 36) = 29.26$, $p < .001$, $\eta_p^2 = 0.45$. Furthermore, they predicted lower performance (judgment of learning) for the disfluent than for the fluent text, $F(1, 36) = 21.50$, $p <.001$, $\eta_p^2 = 0.37$. In contrast group disfluent-fluent, no significant fluency-effects were found for ease of learning judgments, $F(1, 37) = 2.28$, $p = .140$, $\eta_p^2 = 0.06$, for familiarity judgments, $F(1, 37) = 0.53$, $p = .469$, $\eta_p^2 = 0.01$, for comprehension judgments, $F(1, 37) = 0.10$, $p = .750$, $\eta_p^2 < 0.01$, or for judgments of learning, $F(1, 37) = 0.02$, $p = .893$, $\eta_p^2 < .01$. For retrospective confidence judgments, we found a significant main effect of fluency, $F(1, 73) = 10.47$, $p = .002$, $\eta_p^2 = 0.13$. The students´ confidence in the correctness of their answers was lower for disfluent than for fluent texts in both groups. No significant interaction between fluency and type of contrast was found for retrospective confidence judgments, $F(1, 73) = 1.42$, $p = .237$ $\eta_p^2 = 0.02$.

3.3 Monitoring Accuracy and Performance

For accuracy of comprehension judgments, $F(1, 73) = 15.05$, $p < .001$, $\eta_p^2 = 0.17$, and for accuracy of judgments of learning, $F(1, 73) = 7.65$, $p = .007$, $\eta_p^2 = 0.09$, we found a significant interaction between fluency and type of contrast. While students in contrast group fluent-disfluent were overconfident in comprehension judgments on fluent texts, they accurately judged their comprehension of disfluent texts, $F(1, 36) = 22.29$, $p < .001$, $\eta_p^2 = 0.38$. Similarly, students in contrast group fluent-disfluent accurately predicted their performance for disfluent texts, whereas they were overconfident for fluent texts, $F(1, 36) = 10.56$, $p = .003$, $\eta_p^2 = 0.23$. Inversely, in contrast group disfluent-fluent, there was no fluency-effect on accuracy of comprehension judgments, $F(1, 37) = 0.58$, $p = .451$, $\eta_p^2 = 0.02$, or on accuracy of judgments of learning, $F(1, 37) = 0.39$, $p = .535$, $\eta_p^2 = 0.01$. Students were overconfident for the fluent and disfluent text. For accuracy of retrospective confidence judgments, we found neither a significant main effect of fluency, $F(1, 73) = 0.08$, $p = .780$, $\eta_p^2 < 0.01$, nor a significant interaction between fluency and type of contrast, $F(1, 73) = 0.03$, $p = .857$, $\eta_p^2 < 0.01$. When making retrospective confidence judgments, students in both groups were significantly overconfident for the fluent and the disfluent text.

For performance, a significant main effect of fluency was found for the retention question, $F(1, 73) = 4.83$, $p = .031$, $\eta_p^2 = 0.06$, and for the knowledge questions, $F(1, 73) = 13.35$, $p < .001$, $\eta_p^2 = 0.15$. Students showed worse performance for the disfluent than the fluent text. The interaction between fluency and type of contrast was not significant for the retention question, $F(1, 73) = 0.87$, $p = .353$, $\eta_p^2 = 0.01$. This was also the case for the knowledge questions, $F(1, 73) = 2.90$, $p = .093$, $\eta_p^2 = 0.04$. However, because the latter interaction is close to significance, we report the fluency-effect on knowledge questions in both groups separately. We found a significant fluency-effect on knowledge questions only in contrast group fluent-disfluent, $F(1, 36) = 14.15$, $p = .001$, $\eta_p^2 = 0.28$, and not in contrast group disfluent-fluent, $F(1, 37) = 1.93$, $p = .173$, $\eta_p^2 = 0.05$.

4. Discussion

The aim of the present study was to test whether disfluency is a way to activate analytic monitoring and to reduce overconfidence. We assumed that fluency-effects on metacognitive processes and performance are moderated by the type of contrast (see contrast hypothesis). As expected, in contrast group fluent-disfluent, we found fluency-effects on control (except for termination of study), monitoring, and monitoring accuracy after rereading. However, we did not expect that students would show worse performance for the disfluent than for the fluent text. Also as expected, in contrast group disfluent-fluent, we found no fluency-effects on control (except for reading-time that served as a manipulation check), monitoring during learning, or monitoring accuracy. However, students in contrast group disfluent-fluent were overconfident for the fluent and the disfluent text, which was not expected. Based on these results, we conclude that a contrast from fluent to disfluent text seems to be necessary to improve monitoring accuracy for the disfluent text.

However, besides this implication, the findings above have further theoretical implications. Disfluency is often supposed to activate deep, effortful, and analytic processes (System 2 processes, see Alter et al., 2007). Based on our results, we propose that System 2 processes should be distinguished in cognitive and metacognitive processes. We found no evidence for deeper cognitive processing because it would have improved performance for disfluent text. However, we found more analytic monitoring for the disfluent text in contrast group fluent-disfluent: Students in this group made accurate judgments for the disfluent text but not for the fluent text. Hence, disfluency seems to be a way to activate analytic metacognitive but not necessarily deeper cognitive processes when students first learn with a fluent and afterwards with a disfluent text. Moreover, the activation of analytic metacognitive processes seems to occur at the expense of cognitive processes, which might explain worse performance for disfluent than fluent text.

Furthermore, we found that students in contrast group fluent-disfluent reported higher mental effort and higher perceived difficulty for disfluent texts than for fluent texts. Inversely, students in contrast group disfluent-fluent neither reported higher mental effort and higher perceived difficulty nor made more accurate judgments for disfluent than fluent text. Therefore, fluency-effects on monitoring accuracy as well as on mental effort and perceived difficulty were affected by the type of contrast. Inversely, the fluency-effect on termination of study was not affected by the type of contrast. Hence, mental effort and perceived difficulty might be more related to monitoring than to cognitive processes. However, mental effort seems to capture another aspect of monitoring than, e.g., judgments about difficulty and performance. This is supported by the finding that there is no significant correlation between mental effort and other judgments (see Appendix A, Table A1): On the one hand students can attribute high mental effort to difficulties during rereading. In this case, they should predict low performance. On the other hand, students can interpret high invested mental effort as a compensation for these difficulties (see also Koriat et al., 2006). In this case, they should predict high performance (see also Koriat, Nussinson, & Ackerman, 2014). Different attribution styles between students, therefore, can explain why there is no correlation between mental effort and judgments about difficulty (e.g., ease of learning judgments) and performance (e.g., judgments of learning). However, further research is required to gain deeper insights into students` attribution of mental effort. Moreover, future research should also consider different measures for monitoring and control. Next, we discuss results on monitoring, control, and performance in each contrast group in more detail.

4.1 Fluency-Effects on Monitoring, Control, and Performance in Contrast Group Fluent-Disfluent

In contrast group fluent-disfluent, the results widely support our monitoring and control hypotheses, but they do not support our performance hypothesis. Students in this group read the disfluent text significantly longer, and this result is consistent with previous research that found longer reading-times for disfluent than fluent texts (e.g., Authors, 2016; Eitel & Kühl, 2016; Sanchez & Jaeger, 2015). Furthermore, students in contrast group fluent-disfluent made lower judgments for the disfluent than for the fluent text, which is also consistent with previous research (e.g., Authors, 2016; Maki et al., 1990; Experiment 1; Rawson & Dunlosky, 2002, Experiment 4). Moreover, these results are consistent with the assumption that monitoring is based on control (control-based monitoring, see Koriat et al., 2006). In addition to previous research, we found that disfluency affected different types of judgments (i.e., ease of learning judgments, familiarity judgments, comprehension judgments, judgments of learning, and retrospective confidence judgments) during the learning process when a fluent text is presented before a disfluent text. Because these judgments refer to different levels of text-processing (see section 1.1.2), disfluency affects not only monitoring of surface levels but also monitoring of higher levels of text-processing (e.g., text-base level and situation model). This assumption is consistent with the finding that students in contrast group fluent-disfluent made an accurate comprehension judgment and an accurate judgment of learning for the disfluent text, whereas they were overconfident for the fluent text. This seems to be due to more analytic processes that are activated by disfluency (see Alter et al., 2007). Inversely, the experience that a fluent text is easy to process leads to the illusion of knowing, which is consistent with previous research (e.g., Baker et al., 2010; Dunlosky et al., 2011; Miesner & Maki, 2007). Thus, disfluency is a way to reduce overconfidence when a disfluent text succeeds a fluent text. In this case, monitoring of the fluent text is more surface than the more analytic monitoring of the disfluent text (see also Alter et al., 2007).

However, although we found better monitoring accuracy for the disfluent than the fluent text in contrast group fluent-disfluent, the performance was worse for the disfluent than the fluent text. This finding is important because it has theoretical (see above) and also practical implications: Students who show low performance can accurately judge their performance. Hence, they have the opportunity to improve their performance in further learning phases by translating their accurate monitoring into adequate control: Knowing that a text is not fully understood is the first step toward further learning, which is also supposed by theories of metacognition and self-regulated learning (Nelson & Narens, 1990; Winne & Hadwin, 1998). Thus, in educational contexts, it is feasible to develop interventions that improve monitoring. However, instructions that both improve monitoring and help students translate better monitoring into effective control should be developed (Authors, 2016; Schwartz & Efklides, 2012).

In the present study, students did not initiate adequate control based on their monitoring: Although students in contrast group fluent-disfluent judged the disfluent text as more difficult after reading it once, they did not reread the disfluent text longer than the fluent text, which contradicts the discrepancy-reduction model (see Dunlosky & Metcalfe, 2009). Furthermore, our results show that students terminated their study prematurely, although further learning was required to improve performance and although students accurately judged their performance. However, in future research, more fine-graded measures than termination of study should be used because students can use different learning strategies (Efklides, 2012) that do not necessarily affect termination of study (see also Dunlosky & Mueller, 2016, for an overview of different measures). Therefore, we captured perceived difficulty and mental effort, but as described above, these measures might refer to monitoring and not necessarily to cognitive processes.

Summing up, disfluency is a way to improve monitoring accuracy when a fluent text is presented before a disfluent text. However, students need help to translate better monitoring into better learning and thus into enhanced performance.

4.2 Monitoring, Control, and Performance in Contrast Group Disfluent-Fluent

In contrast group disfluent-fluent, students read the disfluent text significantly longer than the fluent text. Inversely, when rereading the texts, students did not terminate their study later for the disfluent text than for the fluent text. Hence, reading-time is useful and valid as a manipulation check. Disfluency directly affected reading-time when reading a text once because the disfluent font type was more difficult to decipher than the fluent font type. When rereading the text, the words might already have been deciphered, and thus, disfluency might not have affected termination of study. Moreover, when rereading a text, students were allowed to make notes, to reread only some passages or to skip some passages, which might also have affected termination of study. Like for termination of study, we found no significant differences between the fluent and the disfluent text for perceived difficulty and mental effort in contrast group disfluent-fluent. However, as described above, these measures seem to refer to metacognitive processes. Therefore, students` metacognitive processes seem to be similar for the disfluent and the succeeding fluent text in contrast group disfluent-fluent. This is consistent to the finding that students in this contrast group made equal judgments for the fluent and the disfluent text after reading (ease of learning judgment and familiarity judgment) and rereading (comprehension judgment and judgment of learning). These findings support our assumption that disfluency activates analytic metacognitive processes that remain for the succeeding fluent material (see also Alter et al., 2007).

Inversely, the finding of overconfidence for the fluent and the disfluent text in contrast group disfluent-fluent does not support the assumption that disfluency activates analytic monitoring. Nevertheless, overconfidence was descriptively reduced for the disfluent and also fluent text in contrast group disfluent-fluent compared with the fluent text in contrast group fluent-disfluent. Thus, students seem to have used at least some valid cues for their judgments. However, further research is required to investigate which cues students used for their judgments instead of fluency. Although students in contrast group disfluent-fluent were overconfident for the fluent and the disfluent text, they seem to be able to accurately judge the relation between their performance of the fluent and the disfluent text: This assumption is supported by the finding that students´ judgments as well as their performance was equal (to some extent) between the fluent and the disfluent text in contrast group disfluent-fluent. However, further research is required to investigate fluency-effects not only on absolute but also on relative monitoring accuracy when learning with texts (Authors, 2016).

Summing up, when a disfluent text is presented before a fluent text, no fluency-effects on metacognitive processes are found. Metacognitive monitoring seems to be similar for the fluent and the disfluent text and thus, disfluency seems to affect monitoring of succeeding fluent text. However, contrast disfluent-fluent is not sufficient to reduce overconfidence.

5. Conclusion

This study focused on fluency-effects on metacognitive processes and the moderating effects of type of contrast in fluency on these processes. Furthermore, the focus was on learning with meaningful text-material to apply findings from metacognition to metacomprehension research. This is important because fluency-effects on metacognitive processes are rarely investigated in more detail, although metacognitive processes might affect fluency-effects on performance. Based on our findings, we conclude that the type of contrast in fluency moderates the fluency-effects on metacognitive processes. Disfluency is a way to lower students´ judgments and to reduce overconfidence when students first learn with fluent and afterwards with disfluent material. However, students´ performance is thereby reduced for the disfluent compared with the fluent text. This finding has important theoretical implications: Disfluency can activate analytic metacognitive monitoring, but it does not necessarily activate deeper cognitive processing. Thus, system 2 processes can be distinguished into metacognitive and cognitive processes. Furthermore, mental effort might be related to not necessarily cognitive but metacognitive processes. Moreover, this finding is important for educational contexts: Students who show low performance are not misled by an illusion of knowing. However, further research is required to develop instructional material that fosters not only better monitoring but that also helps students translate better monitoring into better control and better performance.

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Appendix A

Table A.1

Correlations Between Dependent Variables Across Conditions (N = 75)

Variable	1	2	3	4	5	6	7	8	9	10
Control										
1. Reading-time										
2. Termination of Study	.06									
3. Perceived Difficulty	-.08	-.13								
4. Mental Effort	-.07	.05	<.01							
Monitoring										
5. Ease of Learning Judgment	-.11	.04	.38**	<.01						
6. Familiarity Judgment	-.18	-.16	.25*	<.01	.20					
7. Comprehension Judgment	-.21	-.05	.54**	-.04	.42**	.28*				
8. Judgment of Learning	-.02	-.23	.59**	-.14	.05	.24*	.24*			
9. Retrospective Confidence Judgments	.05	-.13	.37**	.08	.06	.30**	.14	.69**		
Performance										
10. Retention questions	-.13	.04	.16	.16	.29*	.21	.23*	.19	.31**	
11. Knowledge questions	.01	.21	.26*	.13	.17	.07	.14	.31**	.39**	.50**

* $p < .05$. ** $p < .01$.

Table 1.

Descriptive Statistics of Dependent Variables in the Contrast Groups

	Contrast group fluent-disfluent (N = 37)				Contrast group disfluent-fluent (N = 38)			
	Position 1 (fluent)		Position 2 (disfluent)		Position 1 (disfluent)		Position 2 (fluent)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control								
Reading-time[a]	5.86	1.76	7.18	1.82	6.96	1.53	5.51	1.28
Termination of Study[a]	10.37	2.69	10.60	2.61	10.52	2.78	10.46	2.84
Perceived Difficulty[b, d]	65.24	16.62	44.24	20.38	57.26	19.82	57.58	14.86
Mental Effort[b, e]	60.19	15.54	71.68	18.45	64.62	16.55	61.58	16.94
Monitoring[b]								
Ease of Learning Judgment[d]	54.06	20.68	36.00	27.87	54.61	21.10	47.76	19.53
Familiarity Judgment[f]	42.44	25.30	34.32	23.34	33.61	25.11	30.97	22.43
Comprehension Judgment[d]	71.92	18.41	47.62	22.41	66.21	18.68	65.00	16.97
Judgment of Learning[g]	67.97	12.55	54.41	20.40	61.63	10.65	61.92	11.47
Retrospective Confidence[h] Judgments	64.27	16.22	59.02	17.39	60.01	11.79	62.43	12.27
Monitoring Accuracy[i]								
Comprehension Judgment	16.81**	21.44	-2.35	22.17	13.23**	20.20	10.15**	19.48
Judgment of Learning	12.87**	13.53	4.44	20.00	8.65**	12.33	7.07**	14.48
Retrospective Confidence Judgments	9.16**	16.86	9.05**	16.46	7.03**	9.75	7.58**	13.76
Performance								
Retention Questions[c]	3.59	1.79	3.30	2.00	3.41	1.88	4.16	1.90
Knowledge Questions[b, g]	55.11	10.42	49.97	12.12	52.98	10.36	54.85	11.93

[a]in minutes [b]in percentage [c]absolute frequency [d]0 = *difficult*, 100 = *easy* [e]0 = *none*, 100 = *high*

[f]0 = *not familiar*, 100 = *familiar*, [g]0 = *none*, 100 = *all*, [h]0 = *unconfident*, 100 = *confident*

[i]negative values indicate underconfidence, positive values indicate overconfidence.

** Mean differs significantly from zero ($p < .01$), zero indicates perfect absolute monitoring accuracy.

Figure 1.

Metacognitive processes for (a) contrast fluent-disfluent and (b) contrast disfluent-fluent.

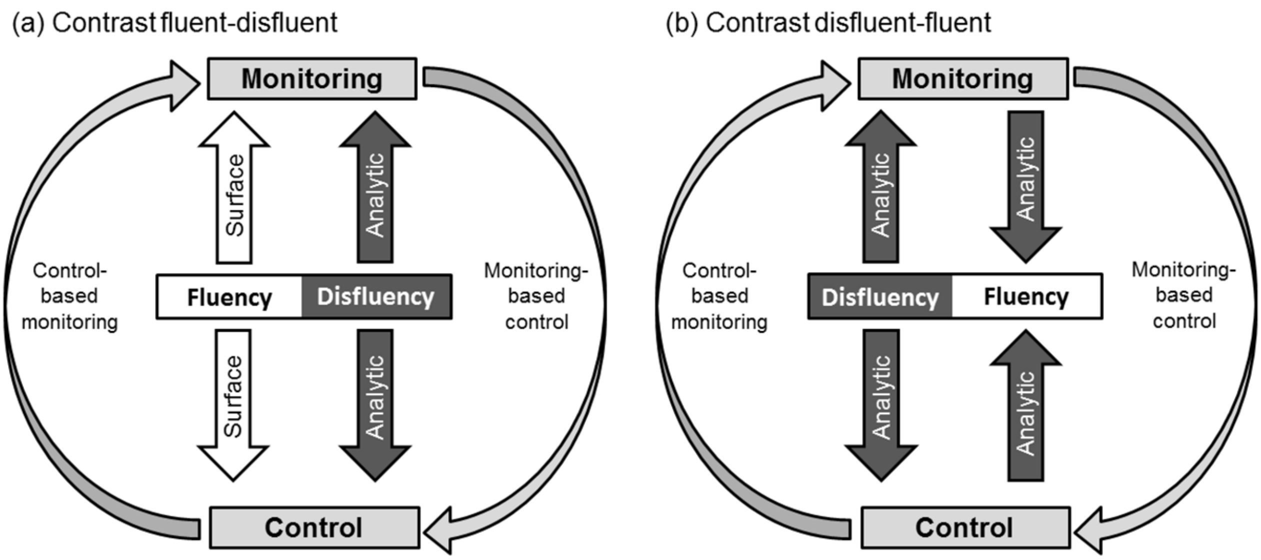

Figure 2.

Procedure of the Study.