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Naive Theories of Intelligence and the Role of Processing Fluency in Perceived Comprehension

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Previous research overwhelmingly suggests that feelings of ease people experience while processing information lead them to infer that their comprehension is high, whereas feelings of difficulty lead them to infer that their comprehension is low. However, the inferences people draw from their experiences of processing fluency should also vary in accordance with their naive theories about why new information might be easy or difficult to process. Five experiments that involved reading novel texts showed that participants who view intelligence as a fixed attribute, and who tend to interpret experiences of processing difficulty as an indication that they are reaching the limits of their ability, reported lower levels of comprehension as fluency decreased. In contrast, participants who view intelligence as a malleable attribute that develops through effort, and who do not tend to interpret experiences of processing difficulty as pertaining to some innate ability, did not report lower levels of comprehension as fluency decreased. In fact, when these participants were particularly likely to view effort as leading to increased mastery, decreases in fluency led them to report higher levels of comprehension.

Keywords: processing fluency, theories of intelligence, comprehension, metacomprehension, metacognition

A crucial aspect of learning is accurately assessing one's mastery of the material being learned. For example, the extent to which people realize that they do not fully understand the text they are reading or that they will not be able to remember the vocabulary words they are studying has significant implications for a number of learning-related decisions, including what information they should focus on next (e.g., Thiede & Dunlosky, 1999), how much longer they should study (e.g., Metcalfe & Kornell, 2005), and what kind of learning strategy they should use (e.g., Miele, Molden, & Gardner, 2009).

Because metacognitive judgments have such an important influence on the ways in which people regulate their own learning (and, thus, on the outcomes of their learning; see Metcalfe & Finn, 2008), researchers have devoted much attention to understanding how these judgments are formed. One of the leading theories in this area (Koriat, 1997) suggests that, contrary to intuition, people rarely form metacognitive judgments by directly assessing the strength and coherence of their memories for recently learned information; instead, they tend to infer how well they have learned something on the basis of a variety of cues that are generally predictive of important learning outcomes. These cues include characteristics of the material being studied (i.e., content cues), characteristics of the learning task (i.e., task cues), and the subjective experience of learning (i.e., internal cues).

Much of the research on metacognition and self-regulated study has focused on this last category. In particular, a number of recent studies have demonstrated the importance of *processing fluency* (i.e., the ease with which information is encoded) as an internal cue that people use to assess their current state of learning (Dunlosky, Baker, Rawson, & Hertzog, 2006; Hertzog, Dunlosky, Robinson, & Kidder, 2003; Koriat, 2008; Koriat, Ackerman, Lockl, & Schneider, 2009; Koriat & Ma'ayan, 2005; Rawson & Dunlosky, 2002). In all of these studies, the greater the subjective ease participants reported in their attempts to understand a text or to memorize a list of words, the higher they rated their own comprehension and the more certain they were about being able to recall the words on an upcoming test. That is, experiences of ease were positively correlated with judgments of learning.[1]

In this article, we investigate how people's naive theories about the meaning of processing fluency (Schwarz, 2004) might alter their interpretations of the subjective ease or difficulty of information processing and the judgments of comprehension that follow. Past research (see Dweck, 1999; Molden & Dweck, 2006) has

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[1] From here on, we use the term *judgment of learning* to refer collectively to metacognitive assessments of memory and comprehension. In the literature, judgments of learning often refer specifically to assessments of memory.

shown that people who believe that intelligence is a fixed and stable entity (i.e., *entity theorists*) tend to interpret feedback about their academic performance as an assessment of their innate abilities and, thus, view challenge as an indication that these abilities are lacking. In contrast, those who believe that intelligence is a malleable construct that can be developed incrementally (i.e., *incremental theorists*) tend to interpret feedback in terms of how much effort they have dedicated to improving their abilities and view challenge as a signal that more effort is required of them. We propose that because entity theorists are likely to view experiences of effortful processing as an indication that they are reaching the limits of their ability to comprehend the information they are encoding, they should report lower levels of comprehension as processing fluency decreases (i.e., as effort increases), as is typically the case. In contrast, we propose that because incremental theorists are unlikely to view experiences of effortful processing as pertaining to some innate ability to understand, they should not report lower levels of comprehension as processing fluency decreases, contrary to what is typical. In fact, to the extent that they view effort as a precursor to mastery, incremental theorists might, in some circumstances, report higher levels of comprehension as fluency decreases and the effort they dedicate to the task increases. Before describing these proposals in detail, we first present a more comprehensive review of the existing research on how processing fluency and naive theories affect judgments of learning.

The Effects of Processing Fluency on Judgments of Learning

As noted above, research has overwhelmingly shown that people often rely on an "easy is better" heuristic when making judgments of learning. Indeed, the consistency of the relationship between feelings of ease and judgments of learning—whether these feelings stem from *perceptual fluency* (e.g., stimulus clarity, figure–ground contrast, and stimulus exposure time; Johnston, Dark, & Jacoby, 1985; Reber, Winkielman, & Schwarz, 1998) or *conceptual fluency* (e.g., concept accessibility, discourse coherence, and context congruity; Rajaram & Geraci, 2000; Whittlesea, 1993)—has led some researchers to suggest that experiences of processing fluency are almost always interpreted positively in the context of learning (i.e., the *ease-of-processing* hypothesis; see Dunlosky et al., 2006; Koriat, 2008; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). That is, if processing feels easy, people assume their mastery is high, but if processing feels difficult, people assume their mastery is low.

One example of evidence supporting the ease-of-processing hypothesis comes from a study by Koriat (2008, Experiment 4) in which he measured processing fluency in terms of the number of study trials it took participants to learn each item from a list of paired associates and found a negative correlation between participants' judgments of learning and the amount of effort they put into learning the different word pairs—the more trials it took to demonstrate initial recall for a particular pair, the lower participants rated their chances of recalling its target on a later test (see also Begg, Duft, Lalonde, Melnick, & Sanvito, 1989; Castel, McCabe, & Roediger, 2007; Hertzog et al., 2003; Koriat & Ma'ayan, 2005; Rhodes & Castel, 2008, 2009). Extending these effects to the more complex domain of text comprehension, Rawson and Dunlosky (2002) had participants read texts in which processing fluency was manipulated either by varying text coherence (i.e., the extent to which ideas in the text are causally related) or by deleting letters from some of the words within each sentence. In both cases, even though participants' objective comprehension was not affected by processing fluency (i.e., their performance on a comprehension test was the same in both conditions), they subjectively perceived their comprehension of the text to be higher in the fluent versus the disfluent conditions. That is, the experience of exerting additional effort led people to infer that their understanding of these texts was inadequate, even though this experience was not a valid predictor of test performance.

Interpreting Experiences of Processing Fluency

Although research on judgments of learning has consistently supported the ease-of-processing hypothesis, research on judgment and decision making has demonstrated more broadly that the heuristics people use to interpret their experiences of processing fluency can be profoundly influenced by their naive theories about what these experiences mean (Briñol, Petty, & Tormala, 2006; Labroo & Kim, 2009; Thomas & Morwitz, 2009; Winkielman & Schwarz, 2001; see Schwarz, 2004, for a review). That is, although numerous variables have been shown to influence experiences of processing fluency, in all cases "which interpretation people choose, and which inferences they draw from their experiences . . . depends on the naive theory they bring to bear" (Schwarz, 2004, p. 338).

In general, there is a broad range of naive theories that people could use to interpret the experience of processing fluency. Some of these theories relate fluency to the properties of the stimuli presented in a task; for example, people assume that the feelings of ease associated with processing words for a second time indicate that these words were displayed with greater clarity (Whittlesea, Jacoby, & Girard, 1990) or presented for a greater length of time (Witherspoon & Allan, 1985) than words that were processed for the first time. Other naive theories relate fluency to one's own mental states; for example, words displayed in a perceptually fluent manner (i.e., with high visual clarity) are rated as being more familiar than words displayed in a disfluent manner (i.e., with low visual clarity; Whittlesea et al., 1990). Thus, even when the experience of fluency is due to some unrelated variable, such as repetition or visual clarity, it can potentially influence people's metacognitive judgments in a variety of different ways depending on what type of naive theory is activated and applied. Direct evidence for this comes from a study by Winkielman and Schwarz (2001) in which they manipulated processing fluency by having participants recall few events (a low effort–high fluency task) or many events (a high effort–low fluency task) from their childhood. After the fluency manipulation, they activated one of two opposing naive theories by informing participants that either unpleasant or pleasant events are typically difficult to recall. The results showed that the participants who experienced low fluency while attempting to recall many events from their childhood evaluated this period of their lives as less pleasant when their activated theory of memory entailed that negative life events are difficult to remember as compared to when it entailed that positive life events are difficult to remember (see also Briñol et al., 2006; Labroo & Kim, 2009).

Naturally Occurring Theories of Processing Fluency

Studies like the one by Winkielman and Schwarz (2001) clearly demonstrate that there are a variety of heuristics and theories that people can apply to their experiences of fluency, which suggests that people's judgments of learning may not always be inferred from fluency in the same way (i.e., that the ease-of-processing hypothesis may not always be true). Yet an important question that remains is, outside of the confines of the research laboratory, what types of naive theories might people spontaneously apply to experiences of processing fluency (see Huber, 2004)?

Unsurprisingly, one such type of naive theory appears to be based on feedback about whether one's fluency experiences serve as valid cues for identifying objective truths about the world, such as the accuracy of factual statements (Unkelbach, 2007) or the prior occurrence of visual stimuli (Unkelbach, 2006; see also Hertwig, Herzog, Schooler, & Reimer, 2008). Indeed, the fact that these experiences do tend to serve as valid cues for predicting successful recall and comprehension (e.g., words that were easy to encode are recalled more often than words that were difficult to encode; Koriat, 2008; Koriat et al., 2009) appears to be one reason why some people form naive theories that are consistent with the ease-of-processing hypothesis. However, another type of spontaneously activated naive theory about metacognitive experiences could be based on people's fundamental assumptions about the world around them. That is, as opposed to inferring from their own experience that high effort is indicative of poor learning (e.g., Koriat et al., 2009), people might also use their general theories about the nature of human intelligence and its role in the learning process to form specific beliefs about effort and processing fluency (cf. Molden & Dweck, 2006). The primary objective of the present research is to explore this possibility.

Naive Theories of Intelligence

Dweck and colleagues (see Dweck, 1999; Dweck, Chiu, & Hong, 1995; Dweck & Leggett, 1988; Molden & Dweck, 2006) have conducted an extensive program of research that examines how people's fundamental beliefs about the world guide their processing and understanding of information about the self and others. As noted earlier, the specific beliefs that have been the primary focus of this research concern whether people's basic attributes (such as intelligence) are understood as static traits that remain relatively fixed throughout their life (i.e., an entity theory) or whether such attributes are understood as malleable traits that can be cultivated over time (i.e., an incremental theory). Although differences between entity and incremental theorists have been studied in a number of different domains (e.g., stereotype formation, moral judgment, and romantic relationships), special attention has been given to the domain of student achievement. In fact, one of the most consistent findings in the naive theories literature is that entity and incremental theorists respond differently to academic challenge: Entity theorists, who are oriented toward demonstrating their innate intellectual abilities, tend to disengage from an academic task after receiving negative feedback, whereas incremental theorists, who are oriented toward developing their abilities, tend to work even harder on a task after receiving the same information (see Dweck & Leggett, 1988).

Hong, Chiu, Dweck, Lin, and Wan (1999) have shown that these findings can largely be attributed to differences in entity and incremental theorists' beliefs about the role of effort in achievement. In one of their experiments (Study 3), participants took an intelligence test and received either positive or negative feedback about their performance. Consistent with previous findings, entity theorists were much less likely to complete a remedial task (aimed at improving their performance on the intelligence test) when they had received negative as opposed to positive feedback. In contrast, incremental theorists were likely to complete the task regardless of the type of feedback they received. More important, this effect was shown to be mediated by participants' effort attributions. After receiving negative feedback, entity theorists attributed their performance more often to ability than to effort, whereas incremental theorists attributed their performance to effort just as often as they attributed it to ability.

In addition to differing in their attributions of effort, entity and incremental theorists have been found to differ in their interpretations of effort. That is, not only do entity theorists see their performance as diagnostic of their innate and stable abilities, they tend to infer that the effort or difficulty they experience while completing a task is an indication that these abilities are lacking (otherwise the task would have been easy). In contrast, not only do incremental theorists see their performance as diagnostic of the effort they have dedicated to the task, they tend to infer that this effort is an indication they are working hard to improve their abilities. Blackwell, Trzesniewski, and Dweck (2007) demonstrated these additional inferences in a longitudinal study that examined how middle school students' beliefs about intelligence and effort predict academic achievement over time. The results showed that students with an incremental theory of intelligence were more likely than students with an entity theory to endorse statements about how effort leads to positive academic outcomes (e.g., "the harder you work at something, the better you will be at it") and less likely to endorse statements about how effort has an inverse relation to ability (e.g., "to tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart"). Furthermore, differences in students' beliefs about effort predicted differences in their mathematics grades over time—incremental theorists who had positive effort beliefs received higher math grades at the end of eighth grade than at the beginning of the seventh grade, whereas entity theorists who had negative effort beliefs showed no improvement in their grades (see also Hong et al., 1999).

Entity Versus Incremental Theories of Processing Fluency

Given this difference in how entity and incremental theorists interpret their experiences of effort, we hypothesized that people's naive theories of intelligence would also alter the manner in which they interpret processing fluency when making judgments of comprehension. Because people with an entity theory of intelligence are likely to interpret effortful processing as a sign that they are reaching the limits of their ability to understand new information, they should report lower levels of comprehension as fluency decreases. That is, entity theorists should use the "easy is better" heuristic and exhibit the typical pattern of judgment that was found in the studies on processing fluency and judgments of learning described above. However, because people with an incremental theory of intelligence tend to interpret effortful processing as a sign that they are still developing a coherent understanding of a text, they should be unlikely to interpret the experience of effort as resulting from an inability to master the text. Thus, in contrast to what has typically been found in studies on processing fluency and judgments of learning, incremental theorists should not use the "easy is better" heuristic and should not report lower levels of comprehension as processing fluency decreases. Furthermore, in specific instances where experiences of processing effort are likely to be predominantly attributed to one's level of involvement in the task (as opposed others factors, e.g., the difficulty or complexity of the task itself), increased processing effort might even be interpreted by incremental theorists as a sign that they have achieved a deeper understanding of the material and thus lead them to report higher levels of perceived comprehension. That is, when they see processing effort as primarily reflecting their own increased engagement, incremental theorists may, in some cases, use an "effortful is better" heuristic (cf. Briñol et al., 2006; Labroo & Kim, 2009).

It is important to note that although entity and incremental theorists were expected to differ in their perceived comprehension of fluent versus disfluent texts, they were not expected to differ in their actual comprehension of the material presented in the texts. That is, to the extent that people monitor and interpret the experience (as opposed to the outcome) of comprehension, as has been shown in previous research (Koriat, Ma'ayan, & Nussinson, 2006), there should be a dissociation between the factors that affect how well they think they understand a text and how well they actually understand it. Such a dissociation would strongly support our claim that people's naive theories of intelligence affect how they interpret their experiences of processing fluency, as opposed to how much effort they actually put into the comprehension task or how capable they are of understanding the material.

To test these hypotheses, we conducted five experiments using procedures that are standard for studying both processing fluency (Oppenheimer, 2008) and perceived comprehension (e.g., Dunlosky & Lipko, 2007). In all experiments, participants read one or more texts, reported how well they understood each text, and then answered a set of multiple-choice questions designed to test their overall level of comprehension. Participants' naive theories of intelligence were either manipulated (Experiment 2) or measured as an individual difference variable (Dweck, 1999; Experiments 1 and 3–5). In the first four experiments, participants' experiences of processing fluency were manipulated using a variety of techniques. First, we varied the coherence of the text provided to participants in Experiments 1–2. We then manipulated the experience of processing fluency more directly (i.e., without altering the content of the text in any way) by varying the clarity of the font used to display the text in Experiment 3 and the proprioceptive feedback participants generated while reading the text in Experiment 4. Finally, in Experiment 5, we assessed participants' natural experiences of processing fluency in terms of the amount of effort they put into processing a text, as indicated by their self-paced study time.

Experiment 1

The purpose of Experiment 1 was to provide initial support for the claim that people use their naive theories of intelligence to interpret their experiences of processing effort and fluency when making metacognitive judgments of comprehension. Previous research has shown that the causal coherence of a text (i.e., the extent to which ideas in the text are causally related) can affect processing fluency. When the causal links between statements within a text have not been made explicit, readers engage in effortful inferential processing to establish causal coherence (Fletcher, Hummel, & Marsolek, 1990; Myers, Shinjo, & Duffy, 1987). Therefore, we asked participants with either an entity or an incremental theory of intelligence to read either a coherent or an incoherent version of a text about television newscasts. The participants then rated how well they understood the material and answered a series of multiple-choice questions designed to test their overall level of comprehension. Consistent with our central hypothesis, we predicted that entity theorists in the incoherent text condition would interpret the extra effort they put into the comprehension task as a sign that they were reaching the limits of their ability to understand a complex and challenging text and, thus (as in previous research), would report lower levels of comprehension than would entity theorists in the coherent text condition. In contrast, we predicted that incremental theorists in the incoherent text condition would not interpret the extra effort as a sign that that they lacked the ability to understand the text (although they would still perceive it to be challenging) and, thus, would not report lower levels of comprehension than would incremental theorists in the coherent text condition.

Method

Participants. Thirty-three members of the Northwestern University community were paid $10 each to participate. Participants were tested in groups of five to 15 and completed all measures with paper and pen.

Procedure. Participants were told that they would be reading a short text and answering questions about it. They were then randomly assigned to read either the coherent or the incoherent version of the text. Once participants finished reading, they were asked to report their perceived comprehension of the text and to complete eight multiple-choice questions designed to assess their actual comprehension. Finally, so as not to bias their responses during the comprehension task, we had the participants complete the Theories of Intelligence Questionnaire (Dweck, 1999) at the very end of the experimental session. A t test revealed that participants' responses to this questionnaire were not affected by the coherence manipulation, $t(31) = 0.39$, $p = .70$.

Coherence manipulation. The brief expository text ($\sim$338 words), which described some of the ways in which television news affects its viewers, was originally selected from a preparatory manual for the Scholastic Aptitude Test (SAT), a standardized exam used for college admissions in the United States. Rawson and Dunlosky (2002) created coherent and incoherent versions of the text by following the guidelines for principled revision originally developed by Britton and Gülgöz (1991). To create the coherent version (Flesch readability score = 22.1; Flesch–Kincaid grade-level score = 16.6), they ordered the information in each sentence so that given information (i.e., information that restated or repeated information from the previous sentence) always preceded new information. To create the incoherent version of the text (Flesch readability score = 24.0; Flesch–Kincaid grade-level score = 16.3), they modified the coherent version so that new information in each sentence always preceded the given information. Both versions of the text are presented in the Appendix. To confirm the effectiveness of this manipulation, we asked participants to answer the following questions after they finished reading the text (using a 1–8 scale): "How easy was it for you to understand the text?" (1 = *not at all easy*, 8 = *very easy*) and "How much effort did you expend trying to understand the text?" (1 = *no effort*, 8 = *much effort*). We constructed an index of perceived difficulty (α = .52) by reverse scoring the ease item and then averaging across participants' responses to both questions.

Assessing perceived comprehension. Before completing these manipulation checks, participants were prompted to rate their perceived comprehension along several dimensions using a 1–8 scale. Specifically, they were asked, "How well do you feel you understand the text?" (1 = *very poorly*, 8 = *very well*), "How certain are you that you will answer questions correctly about the text?" (1 = *very uncertain*, 8 = *very certain*), and "How confused about the text do you feel?" (1 = *not at all confused*, 8 = *very confused*). We constructed an index of perceived comprehension (α = .80) by reverse scoring the confusion item and then averaging across participants' responses to all three questions.

Assessing actual comprehension. After participants finished rating their comprehension of the text, they answered eight multiple-choice questions that measured comprehension in terms of information that was explicitly stated in the text, as well as information that had to be inferred from the text (from Rawson & Dunlosky, 2002). In this experiment and in all subsequent experiments, participants were not allowed to refer back to the text when answering the comprehension questions. All eight questions are presented in the Appendix.

Assessing naive theories of intelligence. At the end of the experiment, participants completed the eight-item Theories of Intelligence Questionnaire (Dweck, 1999). The questionnaire, which was designed to measure a relative preference for an entity versus incremental theory of intelligence, asks participants to rate their level of agreement (on a 1–6 scale) with statements such as "Intelligence is something basic about a person that cannot be changed" and "No matter how much intelligence you have, you can change it quite a bit." In accordance with the standard scoring procedure for this measure, we created a single index (α = .94) by reverse coding the incremental items and then summing across all eight responses for each participant. In the present study, raw scores ranged from 8 (*most incremental*) to 48 (*most entity*). The Theories of Intelligence Questionnaire was designed so that scores at the midpoint of the scale would represent indifference or ambivalence about the nature of intelligence. Thus, to represent variations in the extent to which participants expressed a definite endorsement for an entity or incremental theory, we first created deviation scores by subtracting 28 (the midpoint of the scale) from each person's raw score. We then standardized these deviation scores by dividing by the standard deviation of all of the scores in the sample. Although this standardized index was used as a continuous measure in the regression analyses reported below, for ease of exposition, we refer to those with more negative scores as incremental theorists and those with more positive scores as entity theorists. For further information regarding the reliability and validity of the measure, see Dweck et al. (1995) and Dweck (1999).

Results

Because we made a priori predictions about the different effects of processing fluency on the perceived comprehension of entity and incremental theorists, planned contrasts and simple-slope analyses are one-tailed for all experiments in this article. All other analyses are two-tailed.

Manipulation check. To determine the effectiveness of the fluency manipulation, we submitted perceived difficulty to a hierarchical regression in which the main effects of theory of intelligence and text condition (dummy coded: 0 = coherent, 1 = incoherent) were assessed in the first step and the Theory of Intelligence × Text interaction was added in the second step. The results revealed only a significant main effect of text condition, $\beta = .47$, $t(30) = 2.88$, $p = .007$, such that participants in the incoherent text condition found the text to be more difficult and effortful to read ($M = 5.15$, $SE = 0.24$) than did participants in the coherent text condition ($M = 4.19$, $SE = 0.23$). It is important to note that this effect was not influenced by participants' naive theories of intelligence, $\beta = .11$, $t(29) = 0.58$, $p = .56$.

Perceived comprehension. To assess our central hypothesis, we submitted perceived comprehension to a hierarchical regression in which the main effects of theory of intelligence and text condition (dummy coded: 0 = coherent, 1 = incoherent) were assessed in the first step and the Theory of Intelligence × Text interaction was added in the second step. The results revealed only a significant interaction, $\beta = -.42$, $t(29) = -2.13$, $p = .04$. As shown in Figure 1, simple-slope analyses conducted at 1.5 standard deviations above (for entity theorists) and 1.5 standard deviations below (for incremental theorists) the midpoint of the theories of intelligence index (see Aiken & West, 1991) indicated that, as predicted, entity theorists in the incoherent text condition reported significantly lower levels of comprehension than did entity theorists in the coherent condition, $\beta = -.82$, $t(29) = -2.66$, $p = .006$, whereas incremental theorists' perceived comprehension did not significantly differ between the two conditions, $\beta = .39$, $t(29) = 1.11$, $p = .14$.

Actual comprehension. We performed an additional analysis to examine participants' performance on the comprehension questions. Although the two versions of the text varied in terms of coherence, they contained the same information; thus, we did not expect participants in the coherent condition to perform better on the test questions than participants in the incoherent condition. That is, to the extent that participants in the incoherent condition possessed the ability and motivation to establish causal coherence by expending additional processing effort, they should have achieved the same level of understanding as participants in the coherent condition (which is what Rawson & Dunlosky, 2002, found).

To test these predictions, we submitted the percentage of questions that participants answered correctly (overall $M = 64.8\%$, $SE = 3.50$) to a hierarchical regression in which the main effects of theory of intelligence and text condition (dummy coded: 0 = coherent, 1 = incoherent) were assessed in the first step and the Theory of Intelligence × Text interaction was added in the second step. As expected, neither the main effects nor the interaction was significant, βs $< |.17|$, ts $< |.89|$, ps $> .38$.

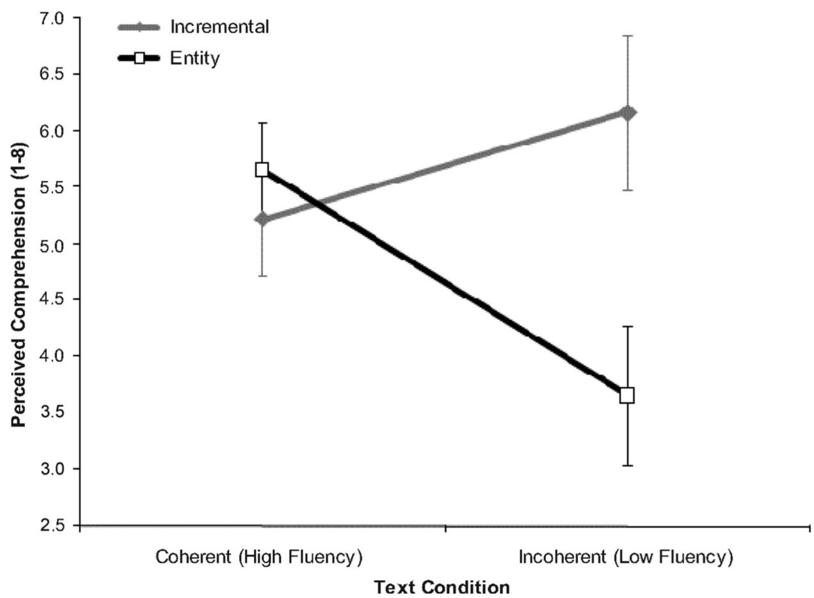

Figure 1. Perceived comprehension of entity and incremental theorists after reading a coherent versus an incoherent text in Experiment 1. Error bars reflect standard errors of the mean.

Discussion

The results of Experiment 1 provide preliminary support for the claim that people's theories of intelligence can influence their interpretations of processing fluency when making judgments of comprehension. Specifically, entity theorists who read the incoherent version of the text reported lower levels of comprehension than did entity theorists who read the coherent version, whereas incremental theorists did not exhibit the same difference in perceived comprehension between conditions. This finding is consistent with our hypothesis that entity theorists interpret effortful processing as an indication that they are reaching the limits of their ability to understand new information and thus report lower levels of comprehension as processing fluency decreases, whereas incremental theorists interpret the experience of mental effort as sign that they are still developing a coherent understanding of the material and thus do not report lower levels of comprehension as fluency decreases.

One alternative explanation for these results is that in the incoherent text condition, incremental theorists reported higher levels of comprehension than entity theorists did because they actually put more effort into understanding the text, not because they interpreted the experience of effort differently. However, if this were true, incremental theorists might also have been expected to perform better on the comprehension questions than entity theorists did. Because no differences in actual comprehension were observed between participants with different theories of intelligence (cf. Rawson & Dunlosky, 2002), this alternative explanation does not provide a compelling account for the present results (although we revisit this issue in subsequent experiments).

Experiment 2

The previous experiment demonstrates that entity theorists interpret their experiences of processing fluency differently than incremental theorists do when making judgments of comprehension. However, because participants' theories were measured as an individual difference variable, it is unclear whether the theories themselves were responsible for this difference in interpretation or whether they were merely correlated with other variables that played a more causal role. Therefore, to demonstrate that people's theories directly influence their interpretations of processing fluency, in Experiment 2, we temporarily manipulated participants' beliefs about the nature of intelligence (see Bergen, 1992; Hong et al., 1999; Niiya, Crocker, & Bartmess, 2004).

Participants were brought into the lab and randomly assigned to read a fake scientific article that presented strong evidence in support of either an entity or an incremental theory of intelligence. After reading the article, participants were assigned to read a coherent or an incoherent version of a brief expository text (as in Experiment 1). Once they finished the text, they again rated how well they understood the material and then answered a series of multiple-choice questions designed to test their overall level of comprehension. We predicted that the results of Experiment 2 would replicate the findings of Experiment 1. Specifically, participants with an induced entity theory of intelligence in the incoherent text condition should expend more effort and report lower levels of comprehension than participants with an entity theory in the coherent text condition. In contrast, participants with an induced incremental theory of intelligence in the incoherent text condition should expend more effort but not report lower levels of comprehension than participants with an incremental theory in the coherent text condition. As in Experiment 1, we expected the entity and incremental theorists within each text condition to invest equal amounts of effort in the task; thus, we did not expect differences in their perceived comprehension to reflect differences in actual comprehension.

Method

Participants. Sixty-seven members of the Northwestern University community were paid $8 each to participate in the experiment. Participants completed all measures on computers that were situated in separate cubicles.

Procedure. Participants were told that the study consisted of two reading comprehension tasks. The first task supposedly involved "reading a scientific article and summarizing the evidence presented by the author," and the second task involved "reading a brief text and answering questions about it (much like the reading comprehension sections of the SAT)." Participants were randomly assigned to read either the entity or the incremental version of the "scientific" article (see below). After they finished reading the article, they responded to several open-ended items that were designed to increase the effectiveness of the theory manipulation. When they were done with the first task, participants from both theory conditions were randomly assigned to read either the coherent or the incoherent version of a text. On finishing the text, they were asked to report their perceived comprehension of the material and to complete eight multiple-choice questions designed to assess their actual comprehension. Finally, as manipulation checks, participants completed the Theories of Intelligence Questionnaire ($\alpha = .96$) and rated how difficult it was for them to read the text. Once the experiment was over, participants underwent a comprehensive debriefing to ensure that they understood that the article they read on the stability or malleability of intelligence was not genuine.

Theories of intelligence manipulation. The two versions of the article that were used to manipulate participants' theories of intelligence were adapted from materials created by Bergen (1992). The article, titled "The Origins of Intelligence: Is the Nature–Nurture Controversy Resolved?" was edited to look like it had originally appeared in the November 2007 issue of *Psychology Today*. It was displayed on the computer as an "original" PDF document containing text, graphics, and even an advertisement. The entity version of the article described the latest scientific "evidence" in support of the idea that intelligence is a genetically determined attribute that changes very little over time. For example, one paragraph stated,

> John Knowles, the author of the article and a professor at Harvard, concludes that "Intelligence seems to have a very strong genetic component. In addition, the environment seems to play a somewhat important role during the first three years of life. After the age of three, though, environmental factors (barring brain damage) seem to have almost no influence on intelligence."

In contrast, the incremental version of the article described "evidence" in support of the idea that intelligence is an environmentally determined attribute that can be improved over time. For example, the John Knowles character concludes that "intelligence seems to have a minimal genetic component. People may be born with a given level of intelligence, but we see increases in IQs up to 50 points when people enter stimulating environments." It is import to note that the two versions of the article focused solely on whether intelligence was stable or malleable and did not include any information about the role of mental effort or processing fluency in comprehension and performance. Thus, the effects of these essays on participants' perceived and actual comprehension cannot readily be attributed to simple demand characteristics. The full text of both versions of the article is available from the authors by request.

Once participants finished reading the article, they responded to three open-ended items. Specifically, each participant was asked to "summarize the main point of the article in one sentence," "describe the evidence from the article that you found most convincing," and "describe an example from your own experiences that fits with the main point of the article." These items were designed to increase the persuasiveness of the article by selectively focusing participants on the evidence in support of its central message.

Fluency manipulation. Processing fluency was manipulated using the same materials as were used in Experiment 1 (see the Appendix). This time, though, both versions of the text were divided into three paragraphs, with each paragraph appearing on a separate screen. Participants were given as much time as they needed before advancing to the next paragraph, but they were not allowed to review previous paragraphs. Because study time is often considered to be an index of processing fluency (e.g., Koriat & Ma'ayan, 2005; Koriat et al., 2006), we recorded the amount of time participants spent reading each paragraph and used the sum of these times to confirm the effectiveness of the manipulation. As an additional manipulation check, we again asked participants to rate (on a 1–8 scale) how easy it was for them to understand the text (1 = *not at all easy*, 8 = *very easy*), as well as how much effort they expended trying to understand it (1 = *no effort*, 8 = *much effort*). We constructed an index of perceived difficulty ($\alpha = .60$) by reverse scoring the ease item and then averaging across participants' responses to both questions.

Assessing perceived and actual comprehension. Perceived comprehension was assessed using the same three items as in Experiment 1. Once again, we constructed an index of perceived comprehension ($\alpha = .83$) by reverse scoring the confusion item and then averaging across participants' responses to all three questions. After participants finished rating their comprehension, they answered the same eight multiple-choice questions used in Experiment 1 (see the Appendix).

Results

One of the participants spent an inordinate amount of time reading the texts (over 3 standard deviations above the mean). Data from this individual were eliminated, leaving responses from 66 participants for analysis.

Manipulation checks. To determine the effectiveness of the theories of intelligence manipulation, we submitted participants' midpoint-centered, standardized scores on the Theories of Intelligence Questionnaire to a 2 (manipulated theory: entity vs. incremental) × 2 (processing fluency: coherent vs. incoherent text) analysis of variance (ANOVA). The results revealed a significant main effect of manipulated theory, $F(1, 62) = 14.51$, $p < .001$, $\eta_P^2 = .19$, such that participants who were presented with evidence supporting an entity theory of intelligence scored higher on the theories of intelligence questionnaire ($M = .47$, $SE = .16$) than did participants who were presented with evidence supporting an incremental theory of intelligence ($M = -.38$, $SE = .16$). It is important to note that this effect was not further qualified by the fluency manipulation, $F(1, 62) = 1.48$, $p = .23$, $\eta_P^2 = .02$. Additional analyses revealed that the mean theories of intelligence score was significantly higher than the midpoint of the index (0) for participants in the entity theory condition, $t(32) = 3.10$, $p = .004$, $d = 0.54$, but significantly lower than the midpoint for participants in the incremental theory condition, $t(32) = -2.46$, $p = .02$, $d = -0.43$. As noted above, because the midpoint of the theories of intelligence index represents indifference or ambivalence about the nature of intelligence, these analyses suggest that (on average) participants who were exposed to the entity manipulation unambiguously endorsed an entity theory, whereas participants who were exposed to the incremental manipulation unambiguously endorsed an incremental theory.

To determine the effectiveness of the fluency manipulation, we first submitted study time to a 2 (theory of intelligence: entity vs. incremental) × 2 (processing fluency: coherent vs. incoherent text) ANOVA. The results revealed a significant main effect of text condition, $F(1, 62) = 7.99$, $p = .006$, $\eta_P^2 = .11$, such that participants in the incoherent text condition spent more time reading ($M = 124.9$ s, $SE = 6.67$) than did participants in the coherent text condition ($M = 99.1$ s, $SE = 6.27$). This effect was not further influenced by participants' naive theories of intelligence, $F(1, 62) = 1.58$, $p = .21$, $\eta_P^2 = .03$. Next, we submitted perceived difficulty to the same 2 × 2 ANOVA. Again, the results revealed a significant main effect of text condition, $F(1, 62) = 35.90$, $p < .001$, $\eta_P^2 = .37$, such that participants in the incoherent text condition found the text to be more difficult and effortful to read ($M = 5.05$, $SE = 0.20$) than did participants in the coherent text condition ($M = 3.38$, $SE = 0.19$). This effect was also not further influenced by participants' naive theories of intelligence, $F(1, 62) = 0.57$, $p = .45$, $\eta_P^2 = .009$.

Perceived comprehension. To assess our central hypothesis, we submitted perceived comprehension to a 2 (theory of intelligence: entity vs. incremental) × 2 (processing fluency: coherent vs. incoherent text) ANOVA. The results revealed a significant main effect of text condition, $F(1, 62) = 11.40$, $p = .001$, $\eta_P^2 = .16$, such that participants in the coherent text condition reported higher levels of comprehension ($M = 6.05$, $SE = 0.20$) than did participants in the incoherent condition ($M = 5.07$, $SE = 0.21$). However, as displayed in Figure 2, this effect was qualified by a significant Theory of Intelligence × Text Condition interaction, $F(1, 62) = 4.69$, $p = .03$, $\eta_P^2 = .07$. Planned contrasts indicated that entity theorists in the incoherent text condition reported significantly lower levels of comprehension ($M = 4.92$, $SE = 0.30$) than did entity theorists in the coherent text condition ($M = 6.53$, $SE = 0.29$), $F(1, 62) = 15.41$, $p < .001$, $\eta_P^2 = .20$, whereas incremental theorists did not differ in perceived comprehension between conditions (Ms = 5.22 and 5.57, SEs = 0.30 and 0.28, respectively), $F(1, 62) = 0.73$, $p = .20$, $\eta_P^2 = .01$.

Actual comprehension. We performed an additional analysis to examine participants' performance on the comprehension questions. Once again, because the two versions of the text contained the same information, the extra effort that participants in the incoherent condition put into the comprehension task (as indicated by their reading times) should have enabled them to achieve the same level of causal coherence achieved by participants in the coherent condition. Thus, as in Experiment 1 (and in keeping with Rawson & Dunlosky, 2002), we did not expect participants in the coherent condition to perform better than participants in the incoherent condition on the test questions.

To test this prediction, we submitted the percentage of questions that participants answered correctly (overall $M = 73.9\%$, $SE = 2.17$) to a 2 (theory of intelligence: entity vs. incremental) × 2 (processing fluency: coherent vs. incoherent text) ANOVA. As expected, neither the main effects nor the interaction was significant, Fs < 0.23, ps $> .64$, η_P^2s $< .01$.

Discussion

Experiment 2 demonstrates that people's theories of intelligence play a causal role in their interpretations of processing fluency during comprehension. Specifically, participants with an induced entity theory of intelligence who read the incoherent version of the

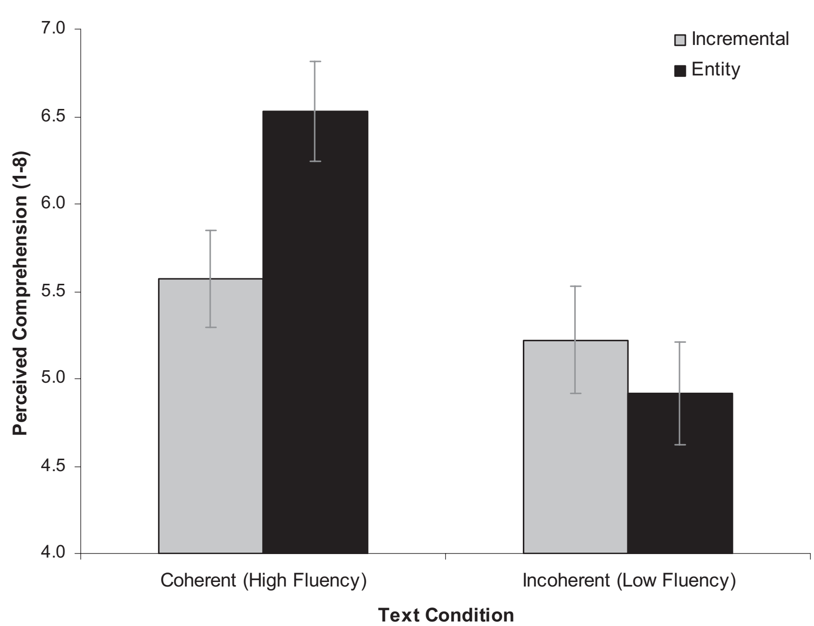

Figure 2. Perceived comprehension of participants with an induced entity or incremental theory of intelligence after reading a coherent versus an incoherent text in Experiment 2. Error bars reflect standard errors of the mean.

text reported lower levels of comprehension than did participants with an entity theory who read the coherent version, whereas participants with an induced incremental theory of intelligence did not exhibit the same difference in perceived comprehension between conditions. This finding further supports our hypothesis that entity theorists interpret effortful processing as an indication that they are reaching the limits of their ability to understand new information and thus report lower levels of comprehension as processing fluency decreases, whereas incremental theorists interpret effortful processing as sign that they are still developing a coherent understanding of the material and thus do not report lower levels of comprehension as fluency decreases.

It is important to note that, despite these differences in perceived comprehension, there were again no differences in actual comprehension between those who read the incoherent version of the text and those who read the coherent version. That is, the differences in perceived comprehension between entity and incremental theorists did not reflect differences in the time and effort they put into processing the text. Furthermore, because the beliefs about intelligence that these participants adopted had been randomly assigned to them, the differences in their perceived comprehension also cannot be explained in terms of individual differences in ability or processing. Thus, it appears that by simply altering what people believe about the nature of intelligence without changing how they actually process new information, it is possible to modify the manner in which they evaluate their own comprehension.

Taken together, Experiments 1 and 2 demonstrate that manipulating the coherence of a text has different effects on the perceived comprehension of entity and incremental theorists. However, in both studies, these effects could potentially stem from people's beliefs or expectations about their ability to understand coherent versus incoherent texts rather than their experience of processing fluency. To further investigate this possibility, in Experiment 3, we used a manipulation of fluency that did not involve altering the content of the text in any way. Perceptual fluency is broadly defined as the ease or speed with which perceptual information is processed (Jacoby & Dallas, 1981; Reber, Wurtz, & Zimmermann, 2004). Past research has shown that when the perceptual information in a task is difficult to process, participants tend to misattribute their feelings of difficulty to the task itself. Thus, by manipulating the clarity of the font used to display the text in Experiment 3, we expected that participants in one condition would experience the text as more effortful to process than would participants in the other condition (see also Alter, Oppenheimer, Epley, & Eyre, 2007; Novemsky, Dhar, Schwarz, & Simonson, 2007; Oppenheimer & Frank, 2008; Song & Schwarz, 2008).

Furthermore, if entity and incremental theorists do differ in their interpretations of processing fluency, it is important to understand whether these interpretations are constructed online (i.e., during comprehension) or whether they only emerge once participants have been explicitly prompted to assess their own understanding of the text. To the extent that people interpret their fluency experiences as they are still encoding new information (and without explicitly being asked to make an assessment of comprehension), there should be many cases outside of the laboratory in which their beliefs about intelligence influence their perceived comprehension and, thus, inform their subsequent learning behavior.

To explore whether naive theories of intelligence operate in this manner, we not only manipulated participants' experiences of processing ease during the comprehension task, we also manipulated the extent to which these experiences served as diagnostic cues for making judgments of comprehension (cf. Schwarz et al., 1991). That is, after they finished reading the text but before they were asked to report their judgments of comprehension, half of the participants were informed that their fluency experiences may have been due to the difficulty associated with reading a text in an unclear font (a cue that is generally not perceived as being diagnostic of comprehension). If entity and incremental theorists retrospectively interpret their fluency experiences only after they have been directly asked to assess their comprehension, then drawing their attention to the font manipulation immediately before they assessed their comprehension should have eliminated any differences in interpretation between the two groups and thus any differences in perceived comprehension (see also Novemsky et al., 2007). However, if entity and incremental theorists interpret their fluency experiences as part of an online encoding process, then drawing their attention to the font manipulation after they had already finished processing the text should not have eliminated these differences in interpretation or perceived comprehension (cf. Anderson, Lepper, & Ross, 1980; Ross, Lepper, & Hubbard, 1975).

Experiment 3

In this study, entity and incremental theorists were asked to read a text that was presented in either a perceptually clear or a perceptually unclear font. As in Experiments 1 and 2, we predicted that entity theorists in the unclear font condition would interpret the extra effort they put into the comprehension task as a sign that they were reaching the limits of their ability to understand a complex and challenging task and, thus, would report lower levels of comprehension than would entity theorists in the clear font condition. In contrast, we predicted that incremental theorists in the unclear font condition would not interpret the extra effort as a sign that that they lacked the ability to understand the text (although they would still perceive it to be challenging) and, thus, would not report lower levels of comprehension than would incremental theorists in the clear font condition.

However, as noted above, half of the participants in each fluency condition were directly informed about the potential influence of text clarity on their feelings of comprehension immediately before they were asked to report their perceived comprehension (the *informed* attribution condition), whereas the other half of the participants were not provided with any information about text clarity (the *uninformed* attribution condition). If participants do not infer their level of comprehension from their experience of processing fluency until after they have been explicitly asked to make a judgment of comprehension, entity and incremental theorists should show the predicted differences in the uninformed condition but not in the informed condition (when the relevance of these fluency experiences for judging comprehension has just been called into question). However, if participants are judging their comprehension in terms of their fluency experiences as they are still encoding the text, entity and incremental theorists should show the predicted differences in both the uninformed and the informed conditions. That is, because participants would have already interpreted their feelings of fluency at a more implicit level before being prompted to question the informational relevance of this experience, the attribution manipulation would not be expected to eliminate the influence of naive theories of intelligence on participants' judgments of comprehension.

Method

Participants. One hundred seventeen members of the Northwestern University community were paid $8 each to participate in the experiment. Participants completed all measures on computers situated at individual workstations.

Procedure. Participants were told that they would be reading a short text and answering questions about it. They were then randomly assigned to read either the clear or the unclear version of the text. After they finished reading, but before they rated their comprehension, half of the participants in each font condition were told, "Some people have found the text difficult to comprehend because of the font in which it was written" (i.e., the informed attribution condition). These participants were then asked to rate (on a 1–8 scale, with 1 = *not at all difficult* and 8 = *very difficult*) how difficult it was for them to read the font used to display the text. The other half of the participants were not provided any information about the font manipulation (i.e., the uninformed attribution condition) and, thus, proceeded directly to the comprehension ratings. All participants then completed eight multiple-choice questions designed to assess their actual comprehension.[2]

Assessing naive theories of intelligence. As part of a pretesting session that was conducted on the Internet several days prior to the lab session, participants completed the same eight-item Theories of Intelligence Questionnaire that was used in Experiment 1 (α = .94; Dweck, 1999).

Perceptual fluency manipulation. We used a brief expository text that Rawson and Dunlosky (2002) had originally adapted from an SAT preparatory manual. The text (which was previously used in the coherent text condition of Experiments 1 and 2) was about television newscasts. Clear and unclear versions of both texts were created by manipulating the font used to display them. The clear version of the text appeared in 12-point black Times New Roman font, whereas the unclear version appeared in italicized 12-point Juice ITC font (see Figure 3; Oppenheimer, 2005). As in Experiment 2, both versions of the text were divided into three paragraphs, with each paragraph appearing on a separate screen. Participants were given as much time as they needed before advancing to the next paragraph but were not allowed to review previous paragraphs. Again, we recorded the amount of time participants spent reading each paragraph and used the sum of these times to confirm the effectiveness of the manipulation. As an additional manipulation check, participants were asked to rate (on a 1–8 scale, with 1 = *not at all difficult* and 8 = *very difficult*) how difficult it was for them to read the font that was used to display the text. Participants in the informed attribution condition were asked as part of the attribution manipulation, whereas participants in the uninformed attribution condition were asked at the end of the experiment.

Assessing perceived and actual comprehension. Perceived comprehension was assessed with the same three items used in Experiments 1 and 2. Once again, we constructed an index of perceived comprehension (α = .89) by reverse scoring the confusion item and then averaging across participants' responses to all three questions. At the end of the experiment, participants answered eight multiple-choice questions that assessed comprehension in terms of information that was explicitly stated in the text, as well as information that had to be inferred from the text.

Clear font: Television newscasts have allowed viewers to form their own opinions

Unclear font: *Television newscasts have allowed viewers to form their own opinions*

Figure 3. Examples of the clear and unclear fonts used to manipulate fluency in Experiment 3

Results

One of the participants did not follow directions and two of the participants spent an inordinate amount of time reading the texts (over 3 standard deviations above the mean). Data from these individuals were eliminated, leaving responses from 114 participants for analysis.

Manipulation check. To determine the effectiveness of the perceptual fluency manipulation, we first submitted study time to a hierarchical regression in which the main effects of theories of intelligence and font condition (dummy coded: 0 = clear, 1 = unclear) were assessed in the first step and the Theory of Intelligence × Font interaction was added in the second step. The results revealed a significant main effect of font condition, $\beta = .40$, $t(111) = 4.66$, $p < .001$, such that participants in the unclear font condition spent more time reading the text ($M = 120.7$ s, $SE = 4.10$) than did participants in the clear font condition ($M = 93.2$ s, $SE = 4.21$). This effect was not further influenced by participants' naive theories of intelligence, $\beta = -.19$, $t(110) = -1.45$, $p = .15$.

Next, we submitted participants' ratings of how difficult it was to read the font to the same regression analysis. Again, the results revealed a significant main effect of font condition, $\beta = .82$, $t(111) = 14.67$, $p < .001$, such that participants in the unclear font condition found the text to be more difficult to read ($M = 6.31$, $SE = 0.19$) than did participants in the clear font condition ($M = 2.32$, $SE = 0.19$). This main effect was qualified by a significant Theory of Intelligence × Font Condition interaction, $\beta = .19$, $t(110) = 2.33$, $p = .02$. Although both entity and incremental theorists in the unclear font condition found the font to be substantially more difficult to read than did entity and incremental theorists in the clear font condition, this difference was somewhat larger for entity theorists, $\beta = 1.01$, $t(110) = 10.45$, $p < .001$, than it was for incremental theorists, $\beta = .62$, $t(110) = 5.95$, $p < .001$. However, controlling for participants' font ratings in the analyses of perceived and actual comprehension reported below did not alter the basic pattern of results.

[2] Before participants completed the comprehension questions, they were provided with a monetary incentive to perform well on the test and given an opportunity to reread the text. Because this measure of study-time allocation did not reveal any effects of font condition, attribution condition, or theory of intelligence and because it did not affect participants' performance on the comprehension questions, it is not discussed further.

Perceived comprehension. To assess our central hypothesis, we submitted perceived comprehension to a hierarchical regression in which the main effects of theories of intelligence, font condition (dummy coded: 0 = clear, 1 = unclear), and attribution condition (dummy coded: 0 = informed, 1 = uninformed) were entered in the first step; the Theory of Intelligence × Font Condition, Theory of Intelligence × Attribution Condition, and Font Condition × Attribution Condition interactions were added in the second step; and the Theory of Intelligence × Font Condition × Attribution Condition was added in the third step. The results revealed a significant main effect of font condition, $\beta = -.22$, $t(110) = -2.40$, $p = .02$, such that participants in the unclear font condition generally reported lower levels of comprehension than did participants in the clear font condition. This effect was qualified by a significant Theory of Intelligence × Font Condition interaction, $\beta = -.29$, $t(107) = -2.04$, $p = .04$. This two-way interaction was not qualified by a significant three-way interaction, $\beta = .18$, $t(106) = 0.97$, $p = .33$. We followed up these results by conducting simple-slope analyses across attribution conditions at 1.5 standard deviations above (for entity theorists) and 1.5 standard deviations below (for incremental theorists) the midpoint of the theories of intelligence index. As shown in Figure 4, entity theorists in the unclear font condition reported significantly lower levels of comprehension than did entity theorists in the clear font condition, $\beta = -.51$, $t(110) = -3.15$, $p = .001$, whereas incremental theorists did not differ in perceived comprehension between conditions, $\beta = .10$, $t(110) = 0.56$, $p = .29$.

Actual comprehension. To examine participants' performance on the comprehension questions, we submitted the percentage of questions that participants answered correctly (overall M = 75.2%, SE = 1.84) to a hierarchical regression in which the main effects of theory of intelligence, font condition (dummy coded: 0 = clear, 1 = unclear), and attribution condition (dummy coded: 0 = informed, 1 = uninformed) were entered in the first step; the Theory of Intelligence × Font Condition, Theory of Intelligence × Attribution Condition, and Font Condition × Attribution Condition interactions were added in the second step; and the Theory of Intelligence × Font Condition × Attribution Condition interaction was added in the third step. It is interesting that the main effect of font condition was significant, $\beta = -.22$, $t(109) = -2.34$, $p = .02$, such that participants who read the perceptually unclear version of the text actually performed worse on the comprehension test (M = 71.1%, SE = 2.52) than did participants who read the clear version (M = 79.6%, SE = 2.56). However, as predicted, this main effect was not qualified by a significant two- or three-way interaction, $\beta\text{s} < |.22|$, $t\text{s} < |1.16|$, $p\text{s} > .24$.

Discussion

The results of Experiment 3 replicated the basic effect found in the previous two studies. Specifically, entity theorists who read a difficult-to-process version of the text reported lower levels of comprehension than did entity theorists who read an easy-to-process version, whereas incremental theorists did not differ in their levels of perceived comprehension between conditions. Once again, these findings support our hypothesis that entity theorists interpret effortful processing as a sign of their limited ability to understand a particular text, whereas incremental theorists interpret it as a sign that their understanding of the text is still developing. The fact that the experiment used a manipulation of fluency that did not involve altering the content of the text strongly suggests that these effects are not simply due to differences in entity and incremental theorists' specific reactions to coherent versus incoherent information.

In addition, the results showed that entity and incremental theorists differed in their judgments of comprehension even when they were informed that their experiences of processing fluency were likely to have been affected by the clarity of the font used to

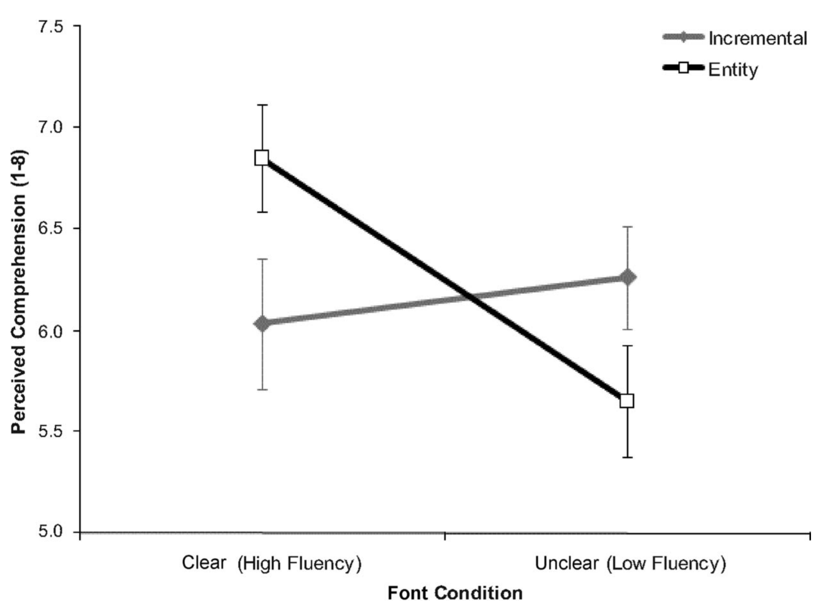

Figure 4. Perceived comprehension of entity and incremental theorists after reading perceptually clear or unclear texts in Experiment 3. Error bars reflect standard errors of the mean.

display the text. Because participants in the informed attribution condition were told about the font manipulation after they had finished reading the text (but before rating their comprehension), the lack of an attribution effect suggests that people do not wait to interpret their fluency experiences until after they have been asked to make a judgment. That is, these results are consistent with the proposition that participants interpreted their fluency experiences as they were still reading the text and that the resulting interpretations were resistant to any correction processes that may have been triggered by the attribution manipulation (cf. Anderson et al., 1980; Ross et al., 1975). However, because caution is always required when interpreting null effects, this proposition should be regarded as tentative at best.

Experiments 1–3 show that the effect of processing fluency on perceived comprehension is moderated by people's naive theories of intelligence. Thus far, we have explained this interaction in terms of differences in how entity and incremental theorists interpret their experiences of processing effort. However, another explanation for the results of the first three experiments is that although entity theorists were particularly sensitive to these experiences when judging their comprehension, incremental theorists were not, which is why they did not show differences in perceived comprehension between fluency conditions. Although this alternative explanation seems somewhat unlikely given the extensive body of research demonstrating the importance of perceived effort as part of incremental theorists' understanding of performance and learning (e.g., Blackwell et al., 2007; Hong et al., 1999; see Dweck, 1999; Molden & Dweck, 2006), we cannot yet definitively rule it out.

Therefore, the primary objective of Experiment 4 was to examine the influence of processing fluency on perceived comprehension in a circumstance in which incremental theorists should not only be unlikely to use the "easy is better" heuristic but actually be inclined to adopt the alternative "effortful is better" heuristic (cf. Briñol et al., 2006; Labroo & Kim, 2009). As noted earlier, this latter heuristic should be most accessible for incremental theorists when they can readily attribute their experiences of processing fluency to the effort they expended while attempting to master the text rather than to factors such as task difficulty or complexity. That is, when increased processing effort is less directly tied to some salient feature of the text itself (such as coherence or visual clarity) and, thus, more likely to be interpreted as a sign of one's increased engagement in the task, it should lead incremental theorists to report higher levels of comprehension. However, because entity theorists believe that increased effort, whatever its source, suggests limited ability, they should continue to report lower levels of comprehension under these circumstances.

Experiment 4

We tested this possibility in Experiment 4 using a manipulation of perceived processing fluency that was based solely on people's proprioceptive effort cues and, therefore, completely independent of the text itself. Several previous studies have shown that altering proprioceptive feedback in terms of people's facial expressions can alter their experiences of perceived effort. For example, Stepper and Strack (1993) asked participants to either furrow their brow (i.e., contract their corrugator muscle) or adopt a light smile (contract the zygomaticus muscle) while engaging in an unrelated self-judgment task. Not only did the participants who furrowed their brow experience higher levels of effort, they attributed this effort to the unrelated task. Adapting these procedures, we asked entity and incremental theorists to read a short text while furrowing their brow (producing cues of increased effort) or puffing their cheeks (an expression that is neutral with respect to effort cues; see Alter et al., 2007). On finishing the text, participants rated how well they understood the material and then answered a series of multiple-choice questions designed to assess their overall level of comprehension.

As explained above, we believed that participants in the present experiment would be more likely than participants in the previous experiments to attribute increases in perceived effort to their engagement in the task (i.e., "I'm working hard at comprehending this text") rather than to the difficulty or complexity of the text itself (i.e., "This text is hard to comprehend"). Therefore, we predicted that entity theorists who had furrowed their brow would report lower levels of comprehension than would entity theorists who had puffed their cheeks, whereas incremental theorists who had furrowed their brow would actually report higher levels of comprehension than would incremental theorists who had puffed their cheeks. Furthermore, as in previous studies, we did not expect the difference in perceived comprehension between entity and incremental theorists to reflect a difference in actual comprehension.

Method

Participants. Eighty-nine undergraduates enrolled at Northwestern University participated in the experiment to partially satisfy a course requirement in introductory psychology. Participants completed all measures on computers situated at individual workstations.

Procedure. At the beginning of the lab session, participants learned that they would be reading a text and answering questions about it. They were also told that because the purpose of the study was to examine how external distractions affect people's comprehension, they would have to maintain a particular facial expression while reading the text. Participants were then randomly assigned to adopt either a furrowed brow or a puffed cheeks expression. The experimenter demonstrated the expressions until it was clear that participants were holding them correctly. As Stepper and Strack (1993) showed, furrowing one's brow is associated with a high degree of mental effort. Puffing one's cheeks, however, is a neutral expression that is equally difficult to maintain but is not associated with mental effort (Tourangeau & Ellsworth, 1979; see also Alter et al., 2007). After participants finished reading the text, they were told to stop maintaining the facial expression. They were then asked to report their perceived comprehension of the text and to complete eight multiple-choice questions designed to assess their actual comprehension (the multiple-choice questions were presented in a randomized order for each participant).

Assessing naive theories of intelligence. As part of a pretesting session that occurred during the first week of the academic quarter (approximately one month prior to the lab session), participants completed the same eight-item Theories of Intelligence Questionnaire that was used in Experiments 1 and 3 (α = .95; Dweck, 1999). Because our predictions were specific to people with a clear-cut theory of intelligence, we selected participants for the lab session who indicated overall agreement with an entity or incremental theory of intelligence (i.e., participants who scored 32 and above or 24 and below on the raw index). It is important to note that these participants still varied in the extent to which they endorsed a stronger or weaker version of an entity or incremental theory of intelligence. Thus, following the approach recommended by Preacher, Rucker, MacCullum, and Nicewander (2005), we constructed a continuous theories of intelligence index (based on the procedure outlined in Experiment 1) to use in the regression analyses reported below.

Texts. We used two brief expository texts that Rawson and Dunlosky (2002) had originally adapted from an SAT preparatory manual. Half of the participants read a text about scientific discovery (373 words; Flesch readability score = 38.2; Flesch–Kincaid grade-level score = 13.3) and the other half read a text about zoos (401 words; Flesch readability score = 47.7; Flesch–Kincaid grade-level score = 12.0). Although this text variable did interact with theories of intelligence in an analysis of perceived comprehension, $\beta = -.37$, $t(76) = -2.29$, $p = .03$,[3] it did not interact with the facial feedback manipulation, $F(1, 76) = 1.16$, $p = .29$, $\eta_P^2 = .02$, or further moderate the interaction between theory of intelligence and facial feedback, $\beta = -.10$, $t(72) = -0.46$, $p = .65$; thus, all of the analyses reported below collapse across the text-condition variable. As in the previous two experiments, both texts were divided into three paragraphs, with each paragraph appearing on a separate screen. Participants were given as much time as they needed before advancing to the next paragraph but were not allowed to review previous paragraphs. Again, we recorded the amount of time participants spent reading each paragraph. However, because our manipulation of processing fluency was independent of the text itself and was intended to alter participants' experiences of effort without influencing the actual effort they put into the task, we predicted that the total reading times of those in the furrowed brow condition would not differ from the total times of those in the puffed cheeks condition.

Assessing perceived and actual comprehension. Perceived comprehension was assessed with the same three items used in Experiments 1–3. Once again, we constructed an index of perceived comprehension ($\alpha = .90$) by reverse scoring the confusion item and then averaging across participants' responses to all three questions. After participants finished rating their comprehension, they again answered eight multiple-choice questions that assessed comprehension in terms of information that was explicitly stated in the text, as well as information that had to be inferred from the text.

Results

One of the participants spent an inordinate amount of time reading the texts (over 3 standard deviations above the mean), two participants did not follow directions, and six participants were inadvertently exposed to a distraction in the lab.[4] Data from these individuals were eliminated, leaving responses from 80 participants for analysis.

Manipulation check. To ensure that the facial feedback manipulation did not lead participants to actually put more effort into processing the text when furrowing their brow (rather than simply feeling as if they were expending more effort), we submitted reading times to a hierarchical regression in which the main effects of theory of intelligence and facial expression (dummy coded: 0 = puffed cheeks, 1 = furrowed brow) were assessed in the first step and the Theory of Intelligence × Facial Expression interaction was added in the second step. The results revealed only a main effect of facial expression, such that participants in the furrowed brow condition actually exhibited shorter reading times ($M = 104.4$ s, $SE = 4.99$) than did participants in the puffed cheeks condition ($M = 119.2$ s, $SE = 5.28$), $\beta = -.23$, $t(77) = -2.04$, $p = .05$. Although unexpected, this effect still indicates that, as intended and in contrast to Experiments 1–3, any disfluency effects evoked by furrowing one's brow are unlikely to be due to the perceived difficulty of processing the text itself. Furthermore, because people's naive theories of intelligence did not have any simple or higher order effects on reading time in this analysis, any differential effects of the facial feedback manipulations for entity and incremental theorists cannot be explained by the unexpected reading time effect.

Perceived comprehension. To assess our central hypothesis, we submitted perceived comprehension to a hierarchical regression in which the main effects of theory of intelligence and facial expression (dummy coded: 0 = puffed cheeks, 1 = furrowed brow) were assessed in the first step and the Theory of Intelligence × Facial Expression interaction was added in the second step. The results revealed only a significant interaction, $\beta = -.36$, $t(76) = -2.28$, $p = .03$. As shown in Figure 5, simple-slope analyses conducted at 1.5 standard deviations above (for entity theorists) and 1.5 standard deviations below (for incremental theorists) the midpoint of the theories of intelligence index indicated that, as predicted, entity theorists in the furrowed brow condition reported significantly lower levels of comprehension than did entity theorists in the puffed cheeks condition, $\beta = -.45$, $t(76) = -2.15$, $p = .02$, whereas incremental theorists in the furrowed brow condition reported higher levels of comprehension than did incremental theorists in the puffed cheeks condition, an effect that approached significance, $\beta = .30$, $t(76) = 1.62$, $p = .055$.

Actual comprehension. To examine participants' performance on the comprehension questions, we submitted the percentage of questions that participants answered correctly (overall $M = 68.3\%$, $SE = 2.16$) to a hierarchical regression in which the main effects of theories of intelligence and facial expression (dummy coded: 0 = puffed cheeks, 1 = furrowed brow) were assessed in the first step and the Theory of Intelligence × Facial Expression interaction was added in the second step. As expected, neither the main effects nor the interaction was significant, $\beta s < |.22|$, $ts < |1.38|$, $ps > .17$.

[3] Incremental theorists rated their understanding of the zoo text to be better than their understanding of the scientific discovery text, whereas entity theorists did not show a difference in perceived comprehension for the two texts.

[4] The distraction (which three of the six participants spontaneously complained about) consisted of loud construction noises coming from the roof of the building. Because this distraction could potentially have caused participants in the low effort condition to experience the reading task as difficult, we excluded all six of these participants from our analyses. However, including the participants did not substantially change the results of the primary analysis: The Theory of Intelligence × Facial Expression interaction for perceived comprehension remained significant, although the slope effect for incremental theorists was slightly reduced.

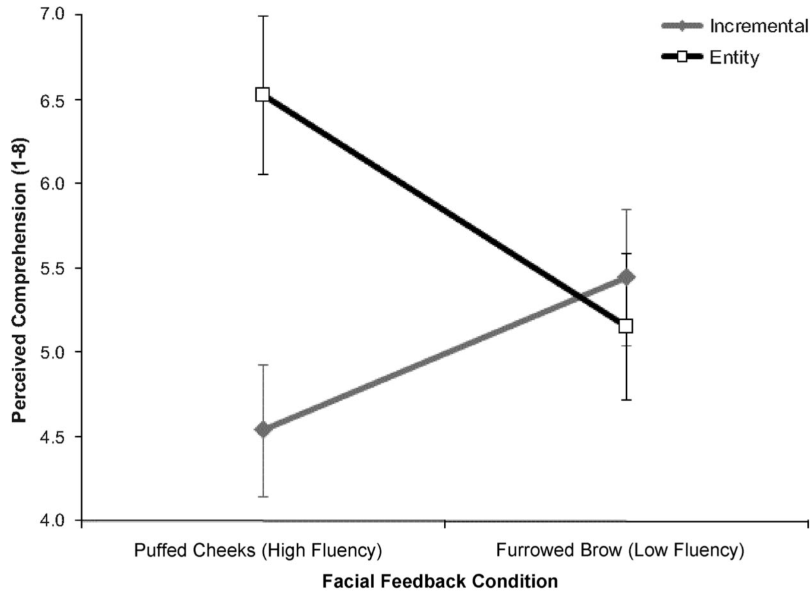

Figure 5. Perceived comprehension of entity and incremental theorists after participants read a text while puffing their cheeks versus furrowing their brow in Experiment 4. Error bars reflect standard errors of the mean.

Discussion

The results of Experiment 4 provide the strongest evidence yet for our central hypothesis. Simply by manipulating participants' feelings of effort through the facial expressions they adopted (and without manipulating any properties of the text), we showed that entity theorists who felt that reading the text was effortful reported lower levels of comprehension than did entity theorists who felt that reading the text was easy, whereas incremental theorists who felt that reading the text was effortful actually reported higher levels of comprehension than did incremental theorists who felt that reading the text was easy. Thus, although both entity and incremental theorists used their experiences of processing effort when judging their comprehension, they clearly interpreted these experiences in different ways. That is, whereas entity theorists again appeared to interpret high levels of perceived processing effort as an indication that they were reaching the limits of their ability to comprehend the material, incremental theorists appeared to interpret high levels of perceived effort as an indication that they were developing a greater mastery and understanding of the text.

The results of this study also tentatively suggest that whereas the previous text-based manipulations of processing fluency in Experiments 1–3 may have led participants to attribute their increased effort to some quality of the text itself, the proprioceptive manipulation of processing fluency in this experiment allowed participants to attribute this effort to their level of engagement in the task. This distinction between the manipulations could potentially explain why incremental theorists did not show differences in perceived comprehension between the low and high fluency conditions in previous experiments but did show such a difference in the present experiment. Although incremental theorists who believe that their increased effort was mostly due to the difficulty of the text are unlikely to infer that they lacked the ability to fully understand it (in contrast to entity theorists), they are also unlikely likely to infer that this difficulty resulted in a relatively high level of comprehension. However, incremental theorists who believe that their increased effort was primarily due to their engagement in the task are likely to infer that this engagement allowed them to develop a relatively deep understanding of the material. This issue is examined further in Experiment 5.

Experiment 5

Overall, Experiments 1–4 demonstrate that participants use their existing or temporarily induced theories of intelligence to interpret their feelings of processing effort when attempting to determine how well they understand a text. Although these experiments used a variety of different fluency manipulations, they did not examine the ways in which people might naturally generate feelings of ease and effort during comprehension. An important question, then, is whether entity and incremental theorists still interpret their fluency experiences differently when these experiences have not been artificially created by an experimental manipulation (e.g., a furrowed brow or an unclear font). To answer this question, we examined a spontaneous and naturalistic indicator of self-generated effort and self-monitoring that is well documented in the literature: study time (e.g., Koriat & Ma'ayan, 2005; Koriat et al., 2006).

The use of self-paced study time as an index of perceived effort also has the advantage of allowing us to further examine the circumstances in which incremental theorists are likely to use an "effortful is better" heuristic when making judgments of comprehension. Because this index should be interpreted as a sign of one's engagement in the task (especially in the absence of any manipulated fluency cues), we predicted that incremental theorists would report higher levels of comprehension as their study time increased (in contrast to entity theorists, who were expected to report lower levels of comprehension).

To test this hypothesis, entity and incremental theorists were asked to complete a reading comprehension task. Instead of having the participants read through the paragraphs of the text in a fixed order (as in the previous experiments), we allowed them to go back and reread previous paragraphs in the hope that they would engage in more naturalistic reading behavior. As a measure of how much effort participants put into studying the text, we recorded the total amount of time they spent reading. Once they had finished the text, participants rated how well they understood the material and then answered a series of multiple-choice questions designed to test their overall level of comprehension.

Method

Participants. Forty-six undergraduates enrolled at Northwestern University participated in the experiment to partially satisfy a course requirement in introductory psychology.

Procedure. Participants arriving in the lab were seated at separate computer terminals. After completing an unrelated task for another experiment, they were told that they would be learning how to play an obscure card game called German Whist. First they would read a text that "describes the rules and strategies for playing German Whist" and then they would demonstrate what they had learned by playing one round of the game against a computer opponent. The instructions stressed that participants were free to read the text at their own pace and that, until they continued past the final screen, they could go back and reread previous paragraphs of the text at any time. Once participants indicated that they had finished reading the text, they were asked to report their perceived comprehension of the material and to complete 14 multiple-choice questions designed to assess their actual comprehension (the multiple-choice questions were presented in a randomized order for each participant). Finally, to maintain consistency with the cover story, the participants played one round of German Whist.

Assessing naive theories of intelligence. As part of a pretesting session that occurred during the first week of the academic quarter, participants completed the same eight-item Theories of Intelligence Questionnaire that was used in Experiments 1, 3, and 4 ($\alpha = .94$; Dweck, 1999).

Assessing processing fluency. The brief text (~1,200 words) that participants read as part of the reading comprehension task described the rules and strategies of the card game called German Whist. The text, which was constructed from documents posted on the Internet, was designed to be conceptually challenging but grammatically undemanding (Flesch readability score = 76.2; Flesch–Kincaid grade-level score = 7.6). For the purposes of the task, the text was split into two 6-paragraph sections. The first section was titled "Rules of German Whist" and the second section was titled "Strategies for German Whist." Each of the 12 paragraphs appeared on a separate screen and was displayed as a scanned page from the *Pocket Guide to Obscure Card Games* (a fictional book that we constructed for the purposes of the experiment).[5] On every screen except for the first screen of each section, participants were presented with the option of continuing on to the next paragraph or going back to reread a previous paragraph. The computer recorded the amount of time they spent reading each paragraph as well as the sequence in which the paragraphs were viewed. The full text is available on request.

Assessing perceived comprehension. After participants finished reading each section, they were prompted to rate their level of comprehension along several dimensions using a 1–7 scale. For instance, after they finished reading the rules section, they were asked, "How well do you feel you understand the rules section?" (1 = *very poorly*, 7 = *very well*), "How confused by the rules section do you feel?" (1 = *not at all confused*, 7 = *very confused*), and "How well do you feel you understand the rules of German Whist?" (1 = *very poorly*, 7 = *very well*). We constructed indexes of perceived comprehension for the rules section ($\alpha = .88$) and the strategy section ($\alpha = .85$) by reverse scoring the confusion items and then averaging across participants' responses to all three questions.

Assessing actual comprehension. After participants finished reading the text and completed the second set of comprehension ratings, they answered 14 multiple-choice questions that assessed comprehension in terms of information that was explicitly stated in the text, as well as information that had to be inferred from the text. Seven of the questions pertained to the rules section of the text and seven pertained to the strategy section.

Results

The overall reading time for one of the participants was over 3 standard deviations above the mean. Data from this individual were eliminated, leaving responses from 45 participants for analysis.

Reading time. Ten participants (22.2%) skipped at least one of the six paragraphs from the strategy section (i.e., viewed a paragraph for less than 3 s), whereas only one participant (2.2%) skipped a paragraph from the rules section, $\chi^2 = 8.39$, $p = .004$. Because our predictions for the experiment were based on the assumption that participants would finish reading the entire text (and, thus, would experience a consistent feeling of effort throughout the task), we focused our analyses on the rules section.[6]

To examine the association between theories of intelligence and reading time, we submitted the amount of time participants spent reading the rules section of the text ($M = 213.3$ s, $SE = 10.76$) to a linear regression analysis. The results showed that entity and incremental theorists did not differ in the time they spent reading the rules section, $\beta = .05$, $t(42) = 0.33$, $p = .74$, and thus were equally likely to experience the reading task as effortful.

[5] Two versions of text were used as part of an ineffective, within-subjects manipulation of fluency. In one version, the paragraphs in the first section became progressively more blurry, whereas the paragraphs of the second section remained clear. In the other version, the paragraphs in the first section remained clear, whereas the paragraphs in the second section became progressively more blurry. At the end of the experiment, participants in both conditions were asked to rate the quality of the text in terms of visual clarity. Because this text manipulation did not have an effect on perceived clarity, $t(43) = 0.46$, $p = .65$, we collapsed across text condition in all of our analyses. In addition, to be sure that perceived clarity did not have any effects on the dependent measures of interest, we controlled for this variable in all of our analyses.

[6] The mean standardized theories of intelligence score for the 10 participants who skipped a paragraph from the strategy section (−.56) did not significantly differ from the mean for the rest of the sample (−.16), $t(43) = 1.28$, $p = .27$, nor did it differ from the midpoint of the scale (0), $t(9) = 1.55$, $p = .16$. In addition, excluding these participants from the analyses of perceived and actual comprehension did not alter the basic pattern of results.

Perceived comprehension. To assess our central hypothesis, we submitted perceived comprehension of the rules section to a hierarchical regression in which the main effects of theories of intelligence and reading time were assessed in the first step and the Theory of Intelligence × Reading Time interaction was added in the second step. The results showed only a significant Theory of Intelligence × Reading Time interaction, $\beta = -.46$, $t(40) = -2.73$, $p = .009$. As shown in Figure 6, simple-slope analyses conducted at 1.5 standard deviations above (for entity theorists) and 1.5 standard deviations below (for incremental theorists) the midpoint of the theories of intelligence index showed that entity theorists reported significantly lower levels of comprehension the more time they spent reading the text, $\beta = -.81$, $t(40) = -2.31$, $p = .01$, whereas incremental theorists reported significantly higher levels of comprehension the more time they spent reading, $\beta = .58$, $t(40) = 2.42$, $p = .01$.

Actual comprehension. We performed an additional analysis to examine participants' performance on the comprehension questions. To the extent that spending more time reading a text is an effective strategy for increasing comprehension, we expected the participants who expended more effort understanding the text to perform better on the comprehension questions than participants who expended less effort, regardless of which theory of intelligence they endorsed.

We tested this hypothesis by first submitting the percentage of rules-related questions that participants answered correctly (overall $M = 69.5\%$, $SE = 2.96$) to a hierarchical regression in which the main effects of theories of intelligence and reading time were assessed in the first step and the Theory of Intelligence × Reading Time interaction was added in the second step. As expected, the results showed only a main effect of reading time, $\beta = .38$, $t(41) = 2.54$, $p = .02$. Participants performed better on the rules questions the more time they spent reading the text. This effect was not qualified by a significant interaction, $\beta = -.13$, $t(40) = -0.75$, $p = .46$.

Discussion

The results of Experiment 5 provide external validity for the claim that people's theories of intelligence can influence their interpretations of processing effort when making judgments of comprehension. Specifically, participants with an entity theory of intelligence reported lower levels of comprehension the more time they spent reading the text, whereas participants with an incremental theory of intelligence reported higher levels of comprehension the more time they spent reading. Thus, it appears that entity and incremental theorists interpret their experiences of processing fluency differently, even when these experiences are the by-product of their spontaneous attempts to complete a naturalistic reading task (and not the result of an experimental manipulation). Furthermore, these findings provide additional support for the idea that when incremental theorists interpret their processing effort in terms of task engagement (as opposed to task difficulty), increases in perceived effort will lead them to report higher levels of comprehension.

General Discussion

In the present article, we examined the effect of self-reported and manipulated theories of intelligence on people's interpretations of processing fluency during comprehension. The results of five experiments suggest that people with an entity theory of intelligence, who interpret effortful processing as a sign that they are reaching the limits of their ability to understand a text (Blackwell et al., 2007), infer lower levels of comprehension as fluency decreases, which is the typical pattern of judgment found in past studies of processing fluency and learning. In contrast, people with an incremental theory of intelligence, who are more likely to interpret effortful processing as a sign that their understanding of the text is still developing (Blackwell et al., 2007), tend not to infer lower levels of comprehension as fluency decreases and, in some cases, actually report higher levels of comprehension.

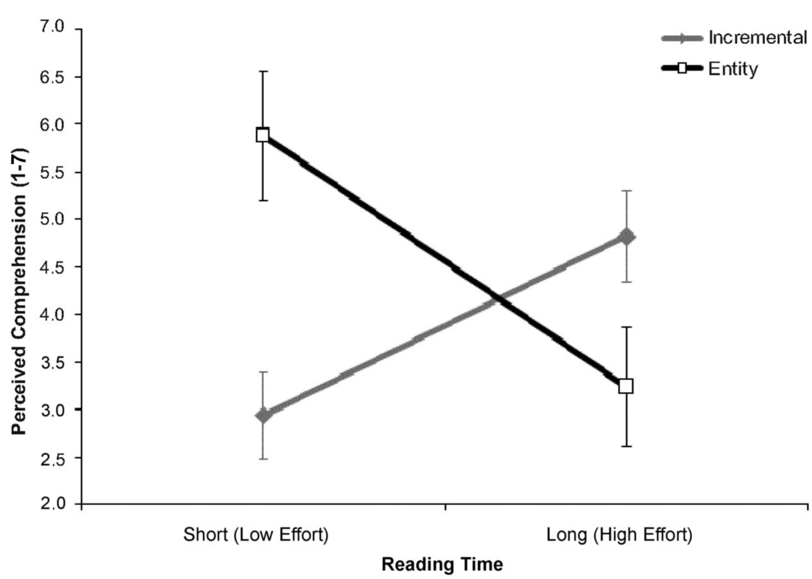

Figure 6. Perceived comprehension of entity and incremental theorists in Experiment 5 plotted at 1.5 standard deviations above and below the mean reading time for the entire sample. Error bars reflect standard errors of the mean.

Across three different manipulations of processing fluency and one measure of processing effort, participants' beliefs about the nature of intelligence affected how they interpreted the experiences of fluency or disfluency on which their judgments of comprehension were based. In Experiments 1 and 2, entity theorists who read a text low in causal coherence reported lower levels of comprehension than did entity theorists who read a version of the same text that was high in causal coherence, whereas incremental theorists did not differ in their levels of perceived comprehension between text conditions. In Experiment 3, entity theorists who read a text displayed in an unclear font reported lower levels of comprehension than did entity theorists who read the exact same text displayed in a clear font; once again, incremental theorists did not show a difference in perceived comprehension between conditions. These results suggest that differences in perceived comprehension were based on participants' interpretations of their fluency experiences (i.e., their feelings of processing ease and difficulty) rather than their beliefs about their ability to understand coherent versus incoherent texts. Further reinforcing this point, in Experiment 4, entity theorists who experienced disfluency from proprioceptive feedback (i.e., furrowing their brow) while reading a text reported lower levels of comprehension compared with entity theorists who did not experience this disfluency. In contrast, incremental theorists who experienced the proprioceptive disfluency actually reported higher levels of comprehension compared with incremental theorists who did not experience this disfluency. Finally, in Experiment 5, when experiences of fluency were measured using a spontaneous and naturalistic index of processing effort (i.e., study time), entity theorists who expended relatively high levels of such effort reported lower levels of comprehension than did entity theorists who expended relatively low levels of effort, whereas incremental theorists again showed the opposite effect.

Two additional aspects of these findings are worth noting. The first is that in Experiment 3, the influences of people's naive theories of intelligence were not eliminated when the relevance of the fluency experience for judging comprehension was directly challenged after they had already processed the text (i.e., when participants were informed after they finished reading that font clarity might have affected their perceived comprehension). Because it has been shown that people tend to discount the relevance of their feelings for making judgments once they realize that these feelings cannot be correctly attributed to the object they are evaluating (e.g., Novemsky et al., 2007; see Schwarz & Clore, 1996), this finding suggests that participants had already formed a firm interpretation of their fluency experience by the time they were informed about the font manipulation and asked to assess their comprehension. Although further evidence is needed, it appears that participants were interpreting their fluency experiences as they were encoding new information and did not simply evaluate these experiences retrospectively when explicitly asked about their comprehension.

Another aspect of these findings worth noting is that despite consistent differences in their levels of perceived comprehension, entity and incremental theorists were never found to differ in the amount of time they spent processing the texts or in the actual level of comprehension they achieved. Therefore, the influences of naive theories of intelligence on judgments of comprehension do not appear to be due to differences in entity or incremental theorists' motivation or ability to perform the task. This conclusion is further supported by previous research on naive theories of intelligence showing that such theories are not generally correlated with academic self-confidence or cognitive ability as measured by the SAT (Dweck et al., 1995). It is also supported by an additional analysis we performed on a new sample of 133 students drawn from the same population that we sampled for all of our experiments. The results of this analysis revealed that naive theories of intelligence were uncorrelated, $r = .03$, $p = .76$, with general academic ability measured by cumulative grade point average. Finally, the fact that participants in Experiment 2 were randomly induced to adopt either an entity or an incremental theory of intelligence conclusively demonstrates that the observed effects of these theories on perceived comprehension are independent of any other broad personality or ability factors that might differ between people who tend to favor one theory over the other.

Differences in Perceived Comprehension Within the High and Low Fluency Conditions

Although the findings across all five studies were generally consistent, several features of the results should be considered further. First, the precise pattern of the interaction between theories of intelligence and processing fluency varied somewhat across experiments. Although the effect of fluency on perceived comprehension always differed for entity and incremental theorists, in some cases, this difference emerged most strongly in the low fluency condition (e.g., Experiment 1), whereas in other cases, it emerged most strongly in the high fluency condition (e.g., Experiments 2 and 4).[7] There are at least two possible explanations for this variation in the pattern of results. First, because the two fluency conditions in each experiment were always defined as being "easy" or "difficult" relative to each other, it is quite possible that the low fluency condition in one experiment was equivalent in perceived difficulty to the high fluency condition in another and vice versa. For example, the high fluency condition in Experiment 1 (the coherent text) may have felt just as difficult as the low fluency condition in Experiment 4 (the furrowed brow) but still easier than the low fluency condition in Experiment 1 (the incoherent text).

However, relative differences in the objective difficulty of the fluency conditions do not explain why the interaction pattern differed between Experiments 1 and 2, which used the same materials for the comprehension task. In this case, it is possible that the article used to induce an entity theory of intelligence in Experiment 2 made participants reticent to admit that they had a difficult time understanding the text (regardless of which text condition they were in; see Ehrlinger, 2008). That is, because the article emphasized the negative consequences of failing to understand something (e.g., low levels of innate intelligence, struggling to compete with brighter peers), participants may not have wanted to admit (to themselves or to others) that their comprehension of the text was as low as it actually was. In Experiment 1 (as well as in Experiments 3, 4, and 5), the consequences of failing to under-

[7] In Experiments 3 and 5, incremental theorists reported both higher levels of comprehension than entity theorists in the low fluency condition and lower levels of comprehension than entity theorists in the high fluency condition.

stand may have been less salient or accessible in memory for entity theorists whose view about intelligence had not been blatantly activated. Thus, even though the entity theorists still interpreted processing difficulty as a sign of limited ability, they may have been less likely to infer that these limitations would lead to something bad.

Effects of Processing Fluency on Perceived Comprehension for Incremental Theorists

Another feature of the present results that should be considered further is that although the effect of processing fluency on perceived comprehension always diverged for entity and incremental theorists, incremental theorists merely failed to show the typical ease-of-processing effect in Experiments 1–3 (i.e., those in the easy-processing conditions did not report levels of perceived comprehension that were higher than the levels reported by those in the difficult-processing conditions; cf. Rawson & Dunlosky, 2002) but showed a significant reversal of this effect in Experiments 4–5. Our tentative explanation for this difference is that participants attributed their feelings of effort to separate sources across the two sets of experiments. Because processing effort was manipulated by altering the coherence or visual clarity of the text in Experiments 1–3, participants may have attributed increases in perceived effort to the difficulty or complexity of the text (i.e., to a *data-driven* source; cf. Koriat et al., 2006). Although incremental theorists (unlike entity theorists) would not be expected to interpret this difficulty as signaling an inability to understand the text, they would also be unlikely to interpret it as signaling a relatively high level of comprehension.

In contrast, because processing effort was manipulated independently of the text in Experiment 4 and measured in terms of self-paced study time in Experiment 5, participants in these experiments may have instead attributed increases in perceived effort to their own engagement in the comprehension task (i.e., to a *goal-driven* source; cf. Koriat et al., 2006). Although entity theorists would still be expected to interpret this effort as signaling an inability to understand the text, incremental theorists would now be somewhat likely to infer that their extra effort had increased their chances of mastering the task and, thus, would be expected to report relatively high levels of comprehension. Although this explanation is fully consistent with the results of the current studies, additional research is clearly needed before firm conclusions can be drawn about how incremental theorists will judge their perceived comprehension after experiencing increased processing effort.

Do Entity and Incremental Theorists Differ in Their Interpretation or Their Generation of Effort Cues?

Thus far, we have explained the effect of naive theories of intelligence on perceived comprehension in terms of differences in the way that entity and incremental theorists interpret a particular set of informational cues associated with effortful processing (i.e., cues resulting from both data-driven and goal-driven regulation). However, it is possible that entity and incremental theorists do not actually diverge in their interpretations of these cues but instead differ in how likely they are to generate one type of cue versus the other (i.e., how likely they are to engage in data-driven vs. goal-driven regulation). According to Koriat and colleagues (Koriat et al., 2006; Koriat & Nussinson, 2009), because people generally assume that they are unlikely to have mastered material that is inherently challenging, data-driven increases in study effort lead people to use the "easy is better" heuristic and to report lower levels of learning. In contrast, because people generally assume that they are more likely to have mastered material that they put extra effort into learning, goal-driven increases in study effort lead them to use the "effortful is better" heuristic and to report higher levels of learning. Therefore, an alternative explanation of the current findings could be that whereas entity theorists are more likely to regulate their comprehension in a data-driven manner and thus show effects of fluency that are in line with the "easy is better" heuristic, incremental theorists are more likely to process information in a goal-driven manner and thus show the opposite effects of fluency (at least at times).

Although this is a plausible and interesting alternative, there are several reasons why we believe it cannot fully explain all of the results we have presented. First, if incremental theorists are generally engaged in more goal-driven processing, they might be expected to spend more time reading and reviewing the texts than entity theorists, who should be processing the material more passively. However, as noted earlier, none of the current studies revealed differences in the amount of time entity or incremental theorists spent reading the texts they were attempting to learn, including Experiment 5, in which they were given opportunities to reread the material as much as they wanted. Furthermore, Experiment 4 used a manipulation of perceived processing effort (proprioceptive feedback) that was found to be independent of any actual time or effort participants put into processing the text. Thus, at the very least, it does not seem possible that differences in the amount of data-driven versus goal-driven regulation engaged in by participants can fully explain the differences between entity and incremental theorists described here. However, because Koriat et al. (2006) noted that these two modes of study regulation are not mutually exclusive and can occur simultaneously, it might be fruitful for future research to further explore the relationship between naive theories of intelligence and data-driven versus goal-driven processing.

Implications for Research on Metacognition and Learning

The present findings extend existing research on metacognition and learning by offering an expanded view of how processing fluency influences people's judgments of learning. As noted at the outset, because previous experiments have generally shown a positive correlation between processing ease and perceived memory or understanding, some metacognition researchers have emphasized the use of a single dominant heuristic (i.e., "easy is better") for interpreting their experiences of fluency. However, the present research supports an alternate view of processing fluency; that is, because people's fluency experiences are interpreted in terms of their naive beliefs about what these experiences mean, the same experience can lead to very different judgment outcomes from one person to the next (even within a particular judgment context; e.g., Briñol et al., 2006; Labroo & Kim, 2009; Unkelbach, 2006).

This alternate view has important implications for understanding how people regulate their learning and achievement. Previous studies have shown that people's perceptions of what they have already learned affect what they choose to study next (e.g., Metcalfe & Finn, 2008; Rhodes & Castel, 2009; Thiede, Anderson, & Therriault, 2003); thus, the differences that entity and incremental theorists exhibit in their perceived comprehension could potentially have long-term effects on their achievement, even if these differences are not currently reflected in their actual comprehension (as was the case in our experiments).

According to the two leading theories of how people choose to allocate their study time (Metcalfe & Kornell, 2005; Thiede & Dunlosky, 1999), when people consider their understanding of some material to be inadequate (i.e., insufficient for meeting their learning goal), they are likely to study the same material again instead of moving on to something new. Thus, because entity theorists interpret effortful processing as a sign of poor comprehension, they might be more likely to restudy material that feels difficult to process rather than material that feels easy to process. However, even when increased effort leads entity theorists to develop an improved understanding of the material (as in Experiment 5), the deficits they experience in perceived comprehension could lead them to devote additional time to studying the same material instead of moving on to something new. Given a classroom context in which students have a limited amount of time to study a large amount of material, this tendency for entity theorists to becomes less confident as they put more effort into the task (cf. the *underconfidence-with-practice* effect; Finn & Metcalfe, 2008; Koriat, Sheffer, & Ma'ayan, 2002) could lead them to engage in inefficient study behavior and, consequently, to underperform on important achievement measures.

In contrast, because incremental theorists interpret effortful processing as a sign of good comprehension, they might be just as likely (if not more likely) to restudy material that feels easy to process compared with material that feels difficult to process. Although such behavior might be adaptive when increased effort can lead to improved comprehension, it may actually result in negative outcomes when increased effort can only produce diminishing returns (e.g., when students are asked to study a topic that they previously mastered). Thus, it appears that both entity and incremental theories of intelligence can have either positive or negative effects on self-regulated learning and student achievement. Because this conclusion runs counter to the accepted classroom doctrine (i.e., that entity theories generally lead to negative outcomes, whereas incremental theories lead to positive outcomes; e.g., Blackwell et al., 2007; Stipek & Gralinski, 1996), the present experiments have important implications for student learning that should be investigated further.

Implications for Research on Naive Theories of Fluency

The present findings also build on the research in social psychology that suggests that people use their naive theories of cognition to interpret their metacognitive experiences (see Schwarz, 2004). For the most part, this research has been relatively silent about how people develop their naive theories in the real world (but see Koriat et al., 2009; Unkelbach, 2006, 2007). Some researchers (e.g., Huber, 2004) have even expressed skepticism about being able to predict which theories people will use to interpret their metacognitive experiences outside of the laboratory. In response, the current experiments suggest that the fundamental theories people possess about how the world works (e.g., human intelligence is a fixed and stable attribute) can inform their more specific beliefs about the meaning of a particular experience (e.g., processing effort is an indication of low intellectual ability). Because people's naive theories are stable and relatively easy to assess, the present research provides a useful template for identifying and predicting individual differences in metacognitive judgment across a wide variety of real-world circumstances.

Another implication of the present findings for research on naive theories has to do with the timing of when people use these theories to interpret their metacognitive experiences. It has been suggested (Schwarz, 2004) that which naive theory people select to interpret their metacogntive experiences often depends on the type of judgment they have been asked to make. For example, people who found it difficult to recall many examples of a particular kind of event might infer that the event is relatively uncommon when asked to make a judgment of frequency (Aarts & Dijksterhuis, 1999), or they might infer that they are not following this type of event very closely when asked to make a judgment of interest (Schwarz & Schuman, 1997). This perspective tacitly assumes that people do not begin to interpret their metacognitive experiences until after they have been explicitly prompted to make a judgment. However, as discussed above, our findings provide some suggestive evidence that people can interpret their metacogntive experiences as they are still processing new information (e.g., as they are reading a text or trying to recall exemplars) and without being explicitly asked to evaluate their own learning (see also Gawronski & Bodenhausen, 2005). Future research should further explore instances in which people's naive theories influence their spontaneous, real-world metacognitive assessments.

Concluding Remarks

Although educators continue to stress the importance of self-regulated learning (e.g., Schunk, 2008), relatively little is known about how people form the metacognitive judgments that they use to control their study behavior. The present research demonstrates that people's judgments of comprehension are based on their interpretations of processing fluency and that these interpretations differ among people with entity and incremental theories of intelligence. Because these theories are stable and relatively easy to assess, this research has significant implications for classroom practice. For instance, it may be possible to increase the metacognitive accuracy of low-performing students (and, thus, improve the efficacy of their study behavior) by assessing and then altering their fundamental beliefs about the nature of intelligence, memory, and learning. Future studies in social, cognitive, and educational psychology should explore these implications.

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(*Appendix follows*)

Appendix

Text Versions and Test Questions for Experiments 1 and 2

(Reprinted from “Are Performance Predictions for Text Based on Ease of Processing?” by K. A. Rawson and J. Dunlosky, 2002, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* p. 80. Copyright 2002 by the American Psychological Association.)

Coherent Version

Television newscasts have allowed viewers to form their own opinions about various political events and political leaders by relaying information and images instantly. In many instances, television newscasts have even fostered active dissent from established government policies. For example, in the 1960s, it is no coincidence that the civil rights movement took hold in the United States with the advent of television, as television newscasts were able to convey both factual information and such visceral elements as outrage and determination. Only when nightly television newscasts showed the civil dissent occurring in places like Selma and Montgomery to all of America’s viewers did the issue of civil rights become a national concern rather than a series of isolated local events. Television newscasts relayed reports from cities involved to an entire nation of viewers, showing viewers the scope of the dissent and informing the dissenters that they were not alone. The ability of television newscasts to foster dissent has also been affected by increasingly widespread access to personal video cameras, as the news presented on television newscasts now comes from personal videos as well as from professional news agencies. Personal video cameras have been used by dissenters across the world to gather visual evidence of human rights abuses. Visual evidence gathered by personal video camera has then been transmitted across otherwise closed borders by television newscasts. The personal video camera is claimed by Jack Nachbar, a professor of popular culture, to be a “truth-telling device that can cut through lies.” Nachbar’s claim presumes, though, that the television viewer can believe what he or she sees. But the videotape that appears on television newscasts can, like still photography, be staged and even faked, so the motivation of the photographer must be taken into account. If photographers who are propagandists for some government utilize computer-generated effects, viewers will have more trouble believing what they see. However, even if seeing television newscasts is not automatically believing, at least seeing is seeing—and seeing is the fastest road to freedom in some repressive governments.

Incoherent Version

Viewers have been allowed to form their own opinions by television newscasts about various political events and political leaders that relay information and images instantly. Active dissent has even been fostered from established government policies by newscasts in many instances. In the 1960s, it is no coincidence for example that the civil rights movement took hold in the United States with the advent of television, as able to convey both factual information and such visceral elements as outrage and determination were newscasts. Rather than a series of isolated local events, the issue of civil rights became a national concern only when nightly television newscasts showed the civil dissent occurring in places like Selma and Montgomery to all of America’s viewers. Informing the dissenters that they were not alone, television newscasts showing viewers the scope of the dissent relayed reports from cities involved to an entire nation of viewers. As the news presented on television newscasts now comes from personal videos as well as from professional news agencies, the ability of television newscasts to foster dissent has also been affected by increasingly widespread access to personal video cameras. Across the world, visual evidence of human rights abuses has been gathered by personal video cameras used by dissenters. Then transmitted across otherwise closed borders by television newscasts is the visual evidence gathered by personal video cameras. Jack Nachbar claims as a professor of popular culture that the personal video camera is a “truth-telling device that can cut through lies.” That the television viewer can believe what he or she sees is presumed by Nachbar’s claim, though. But into account must be taken the motivation of the photographer, as like still photography, videotape that appears on television newscasts can be staged and even faked. If propagandists for some government are photographers who utilize computer-generated effects, the more trouble believing what they see viewers will have. Even if seeing television newscasts is not automatically believing, at least seeing is seeing, however—and the fastest road to freedom is in some repressive governments seeing.

Explicit Test Questions

1. According to the passage, television coverage of the civil rights movement did all of the following EXCEPT
   a. inform dissenters that they were not alone
   b. convey factual information
   c. present emotional elements such as anger
   d. portray the scope of the dissent
   e. express opinions of the political leaders*

2. Jack Nachbar, who is quoted in the passage, is
   a. a popular culture professor*
   b. a government propagandist
   c. a reporter for a professional news agency
   d. a civil rights activist
   e. a prominent political figure

3. The author explicitly states that the believability of television news may be compromised by
   a. effects produced by computers*
   b. videos from personal cameras
   c. photographers for professional news agencies
   d. established government policies
   e. reports that are transmitted across closed borders

4. The passage states that when nightly newscasts portrayed civil dissent in the 1960s,
   a. it created a national concern for civil rights*
   b. it incited dissent in places like Selma and Montgomery
   c. it started a series of isolated local events
   d. viewers formed opinions about political leaders
   e. interest in personal video cameras increased

(*Appendix continues*)

Inferential Test Questions

5. The passage is primarily concerned with ways in which

   a. television newscasts deliberately distort information

   b. television affects viewers by its presentation of news*

   c. truth frustrates efforts by the media to constrain it

   d. viewers of television newscasts cannot sort out fact from fiction

   . governments manage to control television newscasts

6. Which of the following, if true, would most strengthen the assertion about television and the American civil rights movement?

   a. Many filmed reports of civil disobedience were censored by television executives during the 1960s

   b. Recent studies have questioned the objectivity with which television newscasts presented reports of civil disobedience during the 1960s

   c. A biography of a major civil rights leader describes in detail the occasions on which the leader was featured in television newscasts in the 1960s

   d. A 1960s poll shows that those Americans who considered civil rights a national priority had seen television newscasts of civil disobedience*

   e. Many of the reporting techniques used today originated in newscasts covering the 1960s civil rights movement

7. It can be inferred from the passage that television newscasts would be better at informing public opinion if

   a. newscasts presented only competing views and not one-sided views

   b. personal videos were banned from television newscasts

   c. technology was developed to detect when videos had been tampered with*

   d. highly visceral information were not presented during television newscasts

   e. only factual information were presented during television newscasts

8. The author suggests a major reason why television newscasts are effective at influencing public opinion. Based on this argument, which medium below would be the most effective at influencing public opinion?

   a. daily newspapers

   b. radio broadcasts

   c. classroom instruction

   d. grassroots movements based on word of mouth

   e. witnessing newsworthy events firsthand*

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