Processing of Written Irony: An Eye Movement Study

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We examined processing of written irony by recording readers’ eye movements while they read target phrases embedded either in ironic or non-ironic story context. After reading each story, participants responded to a text memory question and an inference question tapping into the understanding of the meaning of the target phrase. The results of Experiment 1 (N = 52) showed that readers were more likely to reread ironic than non-ironic target sentences during first-pass reading as well as during later look-backs. Experiment 2 (N = 60) examined individual differences related to working memory capacity (WMC), Sarcasm Self-Report Scale (SSS), and need for cognition (NFC) in the processing of irony. The results of Experiment 2 suggest that WMC, but not SSS or NFC, plays a role in how readers resolve the meaning of ironic utterances. High WMC was related to increased probability of initiating first-pass rereadings in ironic compared with literal sentences. The results of these two experiments suggest that the processing of (unconventional) irony does require extra processing effort and that the effects are localized in the ironic utterances.

INTRODUCTION

In a scene from the Woody Allen movie “Anything Else,” Amanda (an unpredictable young lady) and Jerry Falk (who is desperately in love with her) are going out for dinner in New York City. It is their anniversary and Jerry has made
a table reservation, but Amanda arrives about 2 hours late. When Amanda finally shows up she asks, “Am I late?” Jerry replies, “Not if we go by Rocky Mountain Time.” What Jerry means, of course, is that she is very late indeed. In other words, he is being ironic.

Verbal irony is not restricted to Woody Allen movies. About 8% of the conversational talk between two friends is ironic (Gibbs, 2000). In American TV shows irony is used on average eight times per hour (Schwoebel, Dews, Winner, & Srinivas, 2000). Moreover, irony is not only a feature of Western culture but it is known all over the world (Schwoebel et al., 2000). Like other forms of nonliteral language (e.g., metaphors), it offers an interesting viewpoint from which to examine how people process and comprehend language. The present study examined the time course of processing of written irony and explored individual differences in the processing of ironic statements.

Processing of Irony

According to a classical theory of text comprehension, the Construction-Integration theory (Kintsch, 1998), readers construct a three-level representation of the text. The surface level representation preserves the actual words and sentences used in the text. The textbase comprises the text propositions and their relations. In the situation model, information presented in the text is merged with reader’s prior knowledge and includes the inferences and interpretations the reader has made of the text information. An ironic utterance in text (e.g., “What great weather for a picnic!”) introduces a momentary violation of text coherence: The surface level representation and textbase are incongruent with the situation model of the text (e.g., the weather has been previously described as cold and rainy) until the reader updates the situation model so that the meaning of the utterance is interpreted as ironic rather than literal. The present study examined how readers solve the momentary incoherence produced by ironic utterances embedded in story context.

Theories of irony comprehension differ in whether the literal meaning of the utterance is expected to be computed to comprehend irony (Gibbs & Colston, 2007). According to the traditional standard pragmatic view (e.g., Grice, 1975), comprehension of an ironic statement requires three steps. First, the literal meaning of the statement is accessed. Then, a discrepancy between the literal meaning and the context is detected, and because the literal meaning does not make sense in the context, it is rejected. Finally, an alternative, nonliteral interpretation is sought, and processing of the ironic meaning of the statement is accomplished. This view has been challenged by the direct access view (Gibbs, 1986), which posits that the processing of literal and nonliteral utterances do not differ. If the context in which the statement is presented supports an ironic interpretation, it can be directly accessed without the need to access the literal
meaning first. The graded salience hypothesis proposed by Giora (1997, 1999) offers yet another view. According to this hypothesis, the most salient meaning of a statement is always accessed first. Usually, the literal meaning is the most salient option, but in some cases, for example, when conventionalized or familiar ironies are used, the ironic meaning could be salient. After the most salient (typically the literal) meaning is accessed and recognized to be incompatible with the context, access to an alternative meaning has to be gained. When the ironic meaning is accessed, the literal meaning is not suppressed but is maintained active in mind simultaneously with the ironic meaning. A parallel-constraint-satisfaction framework (Pexman, 2008) has been proposed as a solution to unify the different views. According to this framework, different cues, such as expectations about the speaker and the familiarity of the statement as ironic, are used in parallel to process the meaning of an utterance. The statement activates multiple cues in a connectionist network, and the possible interpretations of the statement are activated via connections between the cues and the possible interpretations. When the network stabilizes, it settles with the interpretation that has the highest activation value and the alternative meanings are suppressed. All this happens rapidly, and thus ironic meaning is readily accessed given the contextual cues available.

The different theoretical views make different predictions about whether comprehension of irony requires more time than comprehension of literal utterance. Moreover, they make different predictions about the time course of irony comprehension. According to the standard pragmatic view, processing of irony should always take extra time in relation to comprehension of literal utterances. Moreover, because the comprehender has to reconsider the meaning of the ironic phrase (because the literal meaning is always accessed first), the effect of irony should be observed relatively late in the course of processing. For example, readers may return to reread the ironic phrase or parts of the text context to resolve the incongruence between the context and the literal meaning of the phrase. In the case of nonsalient irony, the graded salience hypothesis makes the same predictions. Processing of ironic statements should take longer than that of non-ironic statements, and the effects should materialize relatively late during the course of processing. In contrast, the direct access view predicts that the processing of the ironic phrases does not necessarily take more time than the processing of the literal phrases. However, if the context does not support an ironic interpretation, processing-time costs might be expected. Processing of irony should be immediate, and possible processing-time costs should be observed relatively early in the course of processing, as soon as the ironic statement is encountered. The parallel-constraint-satisfaction framework also predicts that if only few contextual cues support the ironic interpretation, processing of irony might take extra time, but the effect should emerge as soon as the ironic remark is encountered.
The empirical evidence about the exact time course of irony processing is somewhat contradictory. The results seem to depend on the methodology used. For example, Gibbs (1986) used sentence reading time measurements and reported that the reading times of ironic comments (“You are a fine friend”) were actually shorter than the reading times of their non-ironic counterparts (“You are a bad friend”). However, when the reading times of the literally same sentences (e.g., “You are a fine friend”) were compared in ironic (somebody was not being a good friend) and non-ironic (somebody was being a good friend) text contexts, reading times were slower in ironic than in non-ironic contexts (Giora, 1995). Also, Giora, Fein, and Schwartz (1998) reported longer sentence reading times for ironic than for non-ironic comments, and Dews and Winner (1999) showed that it takes longer to judge the evaluative tone of the ironic than of the non-ironic statements. However, the problem with the sentence reading time measurements is that they only provide a global measure of sentence processing and do not allow an analysis of the exact processing time-course.

Giora et al. (1998) used the probe word paradigm to examine the time course of the activation of the ironic and literal meanings. In the study, a probe word related either to the literal or ironic meaning of the target phrase was presented after different delays: 150 ms, 1,000 ms, or 2,000 ms after the target offset. The results showed that reaction times to probe words related to the literal meaning were faster than reaction times to probe words related to the ironic meaning after 150 ms and 1,000 ms. The difference between the literal and ironic conditions leveled out at 2,000 ms, suggesting the ironic meaning became as readily available as the literal meaning only relatively late.

Ivanko and Pexman (2003) used a moving window paradigm in which the reading times were measured for each word within the target sentence as well as the sentence immediately after it. The results showed that the effects of irony (i.e., longer reading time) emerged on the final word of the target statement and on some words in the immediately following non-ironic sentence (i.e., the spillover region). In another study also using the moving window paradigm, Pexman, Ferretti, and Katz (2000) obtained results suggesting that the processing of the ironic meaning of a sentence is reflected in the time spent immediately after the last word of an ironic statement. In contrast to these findings, evidence from a moving window study by Schwobeb et al. (2000) suggested that processing of ironic criticisms takes longer than processing of the same phrase presented in a non-ironic context, and the processing cost is relatively immediate and localized to the ironic phrase itself. Also, evidence from an event-related brain potential study (Katz, Blasko, & Kazmerski, 2004) suggested that the ironic meaning may be processed early on, even before the reader has finished reading the last word of the phrase.

However, even though the probe word, the word-by-word reading time, and the event-related brain potential paradigms used in the previous studies provide excellent temporal acuity, they all have serious drawbacks with respect to
ecological validity. In these paradigms the reader is not allowed to freely inspect
the text, for example, to reread the ironic phrase or the critical earlier context.
Yet, research shows that looking back in text is an integral part of reading
Thus, readers may develop task-specific strategies to cope with the task demands.
The present study aimed to avoid these problems and examined how readers
process ironic phrases by making use of eye-tracking technology, which allows a
detailed analysis of the time course of processing while not posing extra demands
on the reader that are alien to normal reading.

To date, only one study has reported analyses of eye movements during
reading of ironic (in comparison with literal) sentences (Filik & Moxey, 2010).
Filik and Moxey examined whether irony influences the resolution of pronominal
references after positive and negative quantifiers. They divided the target phrases
into two parts: the beginning (area before the irony appeared) and the end of
the sentence. With respect to the effects of irony on sentence reading, results showed
that the ends of the ironic sentences received longer total fixation times than the
ends of the literal sentences (the effects of irony during first-pass reading were not
statistically significant). Moreover, readers tended to reread beginnings of the
ironic (in comparison with literal) sentences. The results of Filik and Moxey thus
suggest that the effects of irony are mainly seen as increased rereading of the
sentences, supporting the view that processing of irony takes extra time and that
comprehending irony requires a reanalysis of the utterance, as proposed by the
standard pragmatic view (Grice, 1975) and the graded salience hypothesis (Giora,

In the present study we used eye tracking to examine the exact time course of
processing of utterances embedded in either ironic or literal text contexts. We
report sentence-level eye-movement measures (Hyönä, Lorch, & Rinck, 2003)
that allow a detailed description of how readers process the utterance when they
first encounter it (first-pass reading), whether they tend to reread the sentence
before moving on to the next sentence, and whether they try to resolve the
meaning of the utterance by returning to it from the later parts of text or by
returning to the context in which the utterance is embedded. This allows us to test
the hypotheses drawn from the different theories.

Individual Differences in Irony Comprehension

People differ in their use of ironic language as well as in how likely they are to
interpret verbal remarks as ironic (Dress, Kreuz, Link, & Gaucci, 2008; Ivanko,
Pexman, & Olineck, 2004). However, theories of irony comprehension do not say
much about individual differences in irony comprehension. One exception is the
parallel-constraint-satisfaction view, which posits that the individual’s tendency
to use irony in communicative situations may cue ironic interpretations. In other
words, readers who are likely to use irony themselves should be more sensitive to irony than readers who are not likely to use irony. In support of this view, Ivanko et al. (2004) found some evidence suggesting that self-reported use of sarcasm, as measured by Sarcasm Self-Report Scale (SSS), may be related to faster processing of ironic sentences. They used the word-by-word moving window paradigm to examine reading of ironic vs. literal utterances. In addition to the word reading time, the pause time in the space between sentences was also measured. Ivanko et al. conducted a set of regression analyses to test whether self-reported use of sarcasm is correlated with the processing time difference between sentences in ironic vs. literal stories. The results suggested that higher scores in SSS were related to smaller processing time difference between ironic and literal stories for the space after the target sentence and on a word in the sentence following the target sentence. In other words, self-reported use of sarcasm was found to be related to a subtle speeding up of irony processing, which was localized in the spillover region.

Working memory capacity (WMC) is another factor that could be related to individual differences in irony comprehension. First, WMC has been shown to be a relatively good predictor of reading comprehension ability (e.g., Daneman & Merikle, 1996). Comprehension of an ironic utterance requires the reader to be capable of maintaining contextual information active in working memory during reading. Otherwise, it would be impossible to detect the inconsistency of the literal meaning of the ironically intended sentence and the context in which it is presented. To our knowledge, there is no previous work on the role of WMC in irony comprehension. However, previous research suggests that high WMC individuals are better in producing and interpreting metaphorical expressions than low WMC individuals (Blasko, 1999; Chiappe & Chiappe, 2007). Pierce, MacLaren, and Chiappe (2010) also reported evidence suggesting that high WMC is related to faster and more accurate recognition of nonliteral meaning of a metaphorical utterance (see also Kazmerski, Blasko, & Dessalegn, 2003).

Some people may be more inclined to engage in effortful processing of text information than others (e.g., see Dai & Wang, 2007), and this might be reflected in how readers process and comprehend ironic utterances. Need for cognition (NFC) refers to “an individual’s tendency to engage in and enjoy effortful cognitive endeavors” (Cacioppo, Petty, & Kao, 1984, p. 306). If comprehending ironic utterances does require extra processing effort, it might well be that some individuals are more likely to invest that extra effort in resolving the meaning of these utterances. Thus, NFC could be correlated with how readers process and comprehend ironic utterances.

In sum, we expected there might be individual differences in how readers process ironic vs. literal utterances. In Experiment 2, we examined the role of SSS, WMC, and NFC in irony processing. Based on previous studies (Ivanko
et al., 2004), we expected that readers who have high SSS would show a smaller
effect of irony on the eye fixation times. As for WMC, we predicted that high
WMC readers would show early detection of irony during the course of reading
and demonstrate less need to return back to the ironic utterances or the previous
context in order to resolve the meaning of the utterance. NFC, on the other hand,
was expected to correlate with an increased tendency to engage in effortful later
processing of the ironic stories, such as increased looking back in text to the
ironic sentences and the previous context.

Overview of the Present Study

In the present study we used eye tracking to examine the time course of irony
processing. Participants read stories in which a target phrase appeared either in
ironic or non-ironic meaning. The meaning of the target phrase was manipulated
with the preceding story context; we thus compared the reading of the same
phrases in ironic and in non-ironic contexts. However, each participant read
each target phrase only once, either in ironic or non-ironic context. All ironies
were ironic criticisms (Dews & Winner, 1999) in which the speaker says
something positive to convey a negative attitude (e.g., “What great weather for
a picnic!” when it is pouring rain outside). After reading each story the
participants responded to two questions: one concerning a detail presented in the
story (a text memory question) and another concerning the meaning of the target
phrase (an inference question). Experiment 1 aimed to test hypotheses derived
from different theories of irony comprehension, and Experiment 2 examined
individual differences, namely the role of SSS, WMC, and NFC, in the
processing of irony.

EXPERIMENT 1

In Experiment 1 we tested the different hypotheses on how readers process
ironic vs. literal utterances. According to the standard pragmatic view and the
graded saliency hypothesis, processing of irony should take more time than
processing of literal utterances. According to these views, processing should
also involve a reanalysis of the utterance, which should be reflected in eye-
movement records as increased rereading and/or looking back to the ironic
utterance and/or to the preceding context. The direct access view and the
parallel-constraint-satisfaction view predict that if there are processing time
costs related to the comprehension of irony, they should be observed relatively
early, as soon as the ironic utterance is encountered (i.e., during first-pass
reading).
Methods

Participants

Fifty-two University of Turku students (age range 19–41 years, 41 women) participated in the study to fulfill a course requirement. All participants were native speakers of Finnish.

Apparatus

Eye movements were collected by the EyeLink II eye tracker (SR Research Ltd., Toronto, Ontario, Canada; for technical specifications, see http://www.sr-research.com/mount_tech_spec.php). The eye-movement registration was done monocularly, usually for the right eye,\(^1\) using a 250-Hz sampling rate. The system compensates for the head movements online, so participants were allowed to sit relatively freely without a chin rest.

Materials

All materials were written in Finnish, the native language of the participants. Some experimental materials were translated and modified versions of the stories used by Weingartner and Klin (2005). Other experimental stories and filler stories were written for the purpose of this study. There were 24 experimental stories and 6 filler stories. Each experimental story included a pre-context segment, a critical context segment, a target phrase, spillover region, and a story ending (Table 1).

The meaning of the target phrase (ironic vs. non-ironic) was manipulated by varying the story context in which it appeared. There were two versions of each story, one in which the target phrase was ironic and another in which it was non-ironic. For example, the target phrase “What great weather for a picnic!” is ironic when the critical context sentence reads, “It was raining heavily and the street was flooding,” but non-ironic when the critical context sentence reads, “The sun was shining and the weather was warm.”

The target phrases varied in length from 10 to 70 characters (\(M = 36.44\), \(SD = 14.94\)). All ironic target phrases were ironic criticisms in which a positive utterance is used to convey a negative attitude (Dews & Winner, 1999). The ironic statements were either counterfactual assertives, in which the speaker falsely described the state of the world (e.g., “What great weather for a picnic!”), or insincere expressives (e.g., “Thank you so much for reminding me about the rent payment”). One target sentence was a rhetorical question, which could be classified as a directive (“Why didn’t you go when such a nice guy came to ask you to dance?”). All target sentences were made ironic by manipulating the

\(^1\)The left eye was used if there were problems with the calibration of the right eye.
context in which they appeared: for none of the target phrases was ironic meaning salient. The ironicity (i.e., how ironic the target sentences were perceived in the non-ironic and ironic contexts) and the perceived fit to the context of the target phrases were tested in a separate rating study.

Fifty university students (45 women, \(M_{\text{age}} = 21.74\) years, \(SD_{\text{age}} = 2.88\)) participated in the rating study for course credit. A web-based survey tool (Webropol, http://www.webropol.com) was used for collecting data. The 24 experimental stories were presented to the respondents one at a time. Each story was presented on the viewer’s screen, and the target phrase was presented in bold type. The participants were asked to read each story and to evaluate the phrase printed in bold type on a 5-point scale with respect to two things: how well the phrase fits into the story context (1 = not at all, 5 = very well) and how ironic or sarcastic the phrase is (1 = not at all ironic/sarcastic, 5 = very ironic/sarcastic). Participants were also given an encyclopedia definition of irony and sarcasm. Each participant evaluated only either the ironic or the non-ironic version of a story, so each participant evaluated 12 ironic and 12 non-ironic stories. The results of the rating study showed that even though the target phrases in the ironic versions were rated as relatively well fitting to the context \((M = 3.66, SD = .52)\), their rating was lower than that of the non-ironic phrases \((M = 4.34, SD = .34)\), \(t(23) = 5.44, p < .001\). The target phrases were clearly perceived as more ironic when presented in the ironic context \((\text{min} = 3.92, \text{max} = 4.96, M = 4.63, SD = .27)\) than when they were presented in the non-ironic context \((\text{min} = 1.12, \text{max} = 2.44, M = 1.61, SD = .44)\), \(t(23) = 32.56, p < .001\), supporting our notion that for none of the target phrases was the ironic meaning inherently salient.

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2The \(t\) tests reported here were computed by items.
Each participant read one of the two text versions; the presentation of the two text versions was counterbalanced across participants. Each participant read 12 experimental stories including an ironic target phrase, 12 stories including a non-ironic target phrase, and 6 filler stories. The filler stories were short stories describing various situations; however, they did not contain irony, so their content was very similar to the non-ironic experimental stories.

After each story the participant responded to two yes or no questions: a text memory question and an inference question (for example questions, see Table 1). Text memory questions tapped into the memory about the situation described in the text (e.g., “Was a friend staying at Anne’s?”). The inference questions were designed to test whether the reader had understood what the protagonist actually meant by the target phrase (i.e., whether the reader had comprehended the irony and correctly inferred the mental state of the speaker, e.g., “Was Anne happy about the weather?”). The questions were designed so that for half of the questions the correct answer was “yes” and for the other half “no”.

Procedure

Each participant was tested individually. Participants were told the study was about story comprehension and they would be asked questions about each story after reading it. Participants were instructed to read each story once through for comprehension. They were told that after reading they should respond to questions about the story by pressing K (yes) and E (no) buttons on a gamepad. After the instructions the eye tracker was set up, calibrated, and two practice stories were presented before starting the actual experiment. The story was presented on the computer screen (stories were short enough to fit on one screen), and after reading it the participant pressed a button and the text disappeared. The text memory and the inference questions were then presented one at a time; after responding to the second question a new story appeared on the screen. The stories were presented in two blocks, each containing 15 stories; the order of the stories within each block was randomized. There was a short pause between the blocks. The experiment lasted approximately 45 minutes.

Results

Eye-Movement Measures

Phrase-level analyses of the readers’ eye movement patterns were conducted. Eye fixations were categorized into first-pass and second-pass fixations. First-pass fixations are those made when reading through the target phrase for the first time, whereas second-pass fixations are directed back to the target phrase from a subsequent phrase (i.e., after its initial processing is completed). We computed two first-pass measures: progressive fixation time and first-pass rereading time.
The forward-going fixations that landed on an unread part of the phrase were summed up to compute the progressive fixation time; for the first-pass rereading time, we computed the sum of fixations that landed on sentence regions that were already fixated during the first-pass reading. The durations of fixations made after the first-pass reading were summed up to yield the look-back fixation time (for further details of the measures used, see Hyönä et al., 2003). Because the number of fixations was highly correlated with the corresponding duration measure (e.g., for the target phrase, lowest correlation was .89 between progressive fixation time and number of progressive fixations), we only report the duration measures. First-pass reading times and look-back times included relatively many zeros indicating that some participants did not reread or look back; thus, we formed separate binomial measures indicating whether first-pass rereading or looking back was performed (1 = yes, 0 = no).

Eye fixations on three different text regions were examined: the target phrase; the spillover region, which is the sentence immediately after the target phrase; and the context-setting sentences. All three fixation time measures were computed for the target phrases. To tap into potential late effects of irony processing “spilling over” from the target phrase, we computed the first-pass fixation time on the sentence immediately after the target phrase (i.e., the spillover region). The context-setting sentences preceded the target phrases, and therefore irony could not influence the first-pass reading of these sentences. Thus, only look-back fixation times on the context-setting sentences were examined.

The eye-movement data were analyzed with linear mixed-effects models using the lme4 package (Bates, Maechler, Bolker, & Walker, 2013) supplied in the R statistical software (R Core Team, 2013). Text type was entered to the models as a fixed effect and was deviation coded (−.50 = literal, .50 = ironic). Participants and items were treated as crossed random effects (Baayen, Davidson, & Bates, 2008). In addition to the models including random intercepts, we also tested models in which by-participants random slopes for irony were estimated; however, model comparisons revealed that the random slopes did not improve the model fits and thus only models with random intercepts are reported. P values for the t tests were estimated using the Monte Carlo Markov chain simulations. For the binomial measures, generalized linear mixed models were used for the analyses, and z values and the corresponding p values are reported.

The observed means and standard deviations (computed across all observations) for the eye-movement measures as a function of text type are presented in Table 2. The estimates for the fixed effects, standard errors of the estimates, and the corresponding t or z values and p values for the models are presented in Table 3. The analysis of the progressive first-pass fixation times revealed that ironic sentences received marginally longer progressive first-pass fixation times than literal sentences. As for the probability of first-pass rereading,
readers were more likely to immediately reread ironic than literal sentences; however, irony did not have an influence on the first-pass rereading times. Ironic sentences were more likely to be looked back to but the look-back times were not significantly longer for ironic than literal sentences. The influence of text type was restricted to the target sentence reading, because there was no effect of text type on first-pass reading time on the spillover region or on the probability or duration of look-backs to the critical context.

**Text Memory and Inference Questions**

The means and standard deviations of the correct answers to text memory and inference questions are presented in Table 2. The correct responses were analyzed with a 2 (text type: ironic vs. literal) × 2 (question type: text memory vs. inference) repeated-measures ANOVA. There was a significant main effect of question type (F(1,59) = 21.83, p < .001, η² = .30), suggesting that inference questions were overall more difficult than text memory questions. A significant question type × text type interaction, (F(1,59) = 26.41, p < .001, η² = .34) indicated no differences were found between the text types in answers to text memory questions (t < 1), whereas the inference questions were significantly more difficult for ironic than for literal texts (t(51) = 5.67, p < .001).

**Discussion**

In Experiment 1, eye tracking was used to examine online processing of written irony. More specifically, we examined how phrases are read when presented in ironic compared with non-ironic contexts. All ironies were ironic criticisms with
TABLE 3
Estimates of Fixed Effects, Standard Errors of the Estimates, and Corresponding \( t \) or \( z \) Values and \( p \) Values for Different Eye-Movement Measures in Experiment 1

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Effect</th>
<th>Estimate</th>
<th>SE</th>
<th>( t / z )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-pass progressive fixation time( ^a )</td>
<td>Intercept</td>
<td>967</td>
<td>83</td>
<td>11.71</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>27</td>
<td>15</td>
<td>1.74</td>
<td>.0950</td>
</tr>
<tr>
<td>Probability of first-pass rereading( ^a )</td>
<td>Intercept</td>
<td>- .04</td>
<td>.25</td>
<td>- .15</td>
<td>.883</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.58</td>
<td>.13</td>
<td>4.31</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>First-pass rereading time( ^b )</td>
<td>Intercept</td>
<td>373</td>
<td>39</td>
<td>9.62</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>18</td>
<td>.31</td>
<td>.59</td>
<td>.5690</td>
</tr>
<tr>
<td>Probability of looking back to target( ^a )</td>
<td>Intercept</td>
<td>-.88</td>
<td>.13</td>
<td>- 6.61</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.27</td>
<td>.13</td>
<td>2.12</td>
<td>.0331</td>
</tr>
<tr>
<td>Look-back time( ^c )</td>
<td>Intercept</td>
<td>664</td>
<td>37</td>
<td>17.85</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>63</td>
<td>.60</td>
<td>1.05</td>
<td>.3234</td>
</tr>
<tr>
<td>First-pass reading time on the spillover region( ^a )</td>
<td>Intercept</td>
<td>1,984</td>
<td>145</td>
<td>13.73</td>
<td>.0001</td>
</tr>
<tr>
<td>Probability of looking back to context( ^d )</td>
<td>Intercept</td>
<td>-.20</td>
<td>.18</td>
<td>- 1.09</td>
<td>.274</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.16</td>
<td>.12</td>
<td>1.26</td>
<td>.209</td>
</tr>
<tr>
<td>Look-back time in context( ^e )</td>
<td>Intercept</td>
<td>470</td>
<td>57</td>
<td>8.21</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>- 40</td>
<td>41</td>
<td>- .97</td>
<td>.3378</td>
</tr>
</tbody>
</table>

\( ^a \) Based on 1,235 observations (52 participants, 24 items).
\( ^b \) Based on 613 observations (51 participants, 24 items).
\( ^c \) Based on 388 observations (52 participants, 24 items).
\( ^d \) Based on 1,244 observations (52 participants, 24 items).
\( ^e \) Based on 574 observations (52 participants, 24 items).

no contextual cues in the stories that would have primed the readers to expect ironic remarks. Previous research suggests that under these circumstances, processing of ironic phrases should take extra time in comparison with non-ironic phrases (e.g., Dews & Winner, 1999; Gibbs, 1986; Giora, 1995; Giora et al., 1998). The eye-tracking methodology allowed us to examine the detailed time course of processing: whether effects of irony emerge already during the processing of the target phrase itself or whether the effects emerge only later either as increased processing time on the sentence immediately after the target phrase (spillover region) or as increased looking back to the target phrase and/or the critical context sentences.

The results showed that effects of irony can be observed already during the first-pass reading of the target phrase: The progressive fixation times were marginally longer in ironic than in literal sentences, and the probability of rereading the target phrase during first-pass reading was increased in ironic compared with literal sentences. In other words, irony exerted an early effect
on text processing (Katz et al., 2004; Schwoebel et al., 2000). The results also showed that the ironic meaning is not necessarily completely resolved during the first-pass reading of the target phrase: Irony also increased the probability of looking back to the target statement from a subsequent text region. These results demonstrate that when there are no cues that would prime an ironic meaning (e.g., familiar irony or cues about the tendency of the speaker to use irony), comprehending ironic remarks is a time-consuming process. The effects are also localized to the target utterance itself. The present results are in line with the eye-movement results reported by Filik and Moxey (2010), who found that irony increased the rereading times of the target sentences.

The relatively early effects of irony on online comprehension observed in Experiment 1 support the view that an alternative meaning of the utterance is computed as soon as the ironic phrase is encountered. Both the standard pragmatic view (e.g., Grice, 1975) and, in case of non-salient ironies as studied in Experiment 1, the graded saliency hypothesis (Giora, 1997, 1999) predict that irony effects should only be observed relatively late during the processing time course. The direct access model (Gibbs, 1986) and the parallel-constraint-satisfaction framework (Pexman, 2008), on the other hand, assume the ironic meaning is activated as soon as possible given the available contextual cues. Our results seem to indicate that readers do compute the ironic meaning as soon as the utterance is encountered; however, the finding that irony increases the immediate rereading of the utterances implies that readers do engage in some sort of reanalysis or extra integrative processing of the ironic compared with literal utterances. The increased probability of first-pass rereading may reflect a validation process (Singer, 2013) in which readers validate their (ironic) interpretation of the utterance before moving on in text. According to Singer (2013), validation is an immediate and a routine process, which, however, might occasionally fail. The present findings showing that inference questions regarding ironic utterances were more often incorrectly answered than questions regarding literal utterances suggest that the validation of the ironic utterance did not always succeed.

In sum, Experiment 1 revealed that when readers are allowed freely to inspect the text, the effects of irony are mainly demonstrated as increased rereading of the ironic phrases both during the first-pass reading and in the form of later look-backs launched from subsequent parts of the text. It is thus possible that the word-by-word reading time methodology used in most previous studies (e.g., Ivanko & Pexman, 2003; Pexman et al., 2000; Schwoebel et al., 2000) has forced readers to adopt a different reading strategy than they would use in normal reading. The eye-tracking methodology provides valuable information about the comprehension processes that occur during normal reading when readers are free to inspect the text as they wish.
EXPERIMENT 2

The results of Experiment 1 showed that processing of irony does require extra processing time in comparison with the processing of literal utterances. The effects were mainly observed as increased immediate rereading of the target sentences and as increased looking back to the target sentences from the later parts of text. The purpose of Experiment 2 was twofold: first, to examine whether there are individual differences in how readers process written irony and, second, to replicate Experiment 1 with a new participant sample. As for the individual differences, we expected that the SSS might influence irony processing by facilitating the detection of irony in text. High SSS readers were expected to show a smaller effect of irony in fixation times than low SSS readers. As for WMC, high WMC readers were expected to be able to maintain multiple meanings active in memory during reading and were thus predicted to show earlier and overall smaller effects of irony in fixation times than low WMC readers. We also examined the possible role of NFC in irony processing. Participants with high NFC were expected to invest more effort than low NFC readers in strategically processing the text information and were predicted to show greater effect of irony in the later eye-movement measures, such as in the later look-backs to the target utterances and to the prior context.

Methods

Participants

Sixty University of Turku students (age range 18–38 years, 49 women) participated in the study to fulfill a course requirement or to get a movie ticket. All participants were native speakers of Finnish (the language studied here).

Apparatus

Eye movements were recorded using an EyeLink II or a desktop-mounted EyeLink 1000 eye-tracker system (SR Research Ltd.). The eye-movement registration was done monocularly, typically for the right eye. Sampling frequency was 500 Hz. The stimuli were presented on a 21-inch CRT screen with a screen resolution of 1,024 × 768 pixels and 85-Hz refresh rate. Participants were seated 70 cm from the screen.

Materials

Texts. The materials consisted of the 36 short stories (24 experimental stories and 12 filler stories) used in Experiment 1. The experimental stories were slightly modified so that all ironic utterances were sarcastic irony. Six
new filler stories were created. As in Experiment 1, each participant only read either the ironic or the literal version of an experimental story; each participant thus read 12 ironic and 12 literal stories and 12 filler stories. The presentation of the story versions (literal vs. ironic) was counterbalanced across participants, and the presentation order of the texts was randomized for each participant.

As in Experiment 1, each story was followed by two questions: a text memory question and an inference question. Participants answered the questions by pressing “yes” or “no” buttons on the keyboard.

**WMC.** The reading span test was used to measure verbal WMC (Daneman & Carpenter, 1980). In the test, participants read aloud sets of unrelated sentences that were presented on a computer screen. After every set, the participant was asked to recall the final word of each sentence from the set. The test started with a set of two sentences. The set size increased as long as the participant could recall all final words of the sentences presented in the previous set. Every set size was repeated three times. The test ended when the participant could not recall the final words of the sentences of a particular set size for any of its repetitions. The test was preceded with a practice session of three sets of two sentences. The test was scored for the total number of correctly recalled final words (minimum score = 0, maximum score 81 = points).

**NFC.** The revised version of the Need for Cognition test was used to measure the cognitive style of the participant (Cacioppo, Petty, & Kao, 1984). The test was translated into Finnish. The test was a paper and pencil task that consisted of 18 items. The items were short statements, for example, “I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.” Participants answered the items on a 5-point Likert scale ranging from 1 (strong disagreement) to 5 (strong agreement). The test was scored by summing up all answers. Reverse scoring was used for 9 items. The test score varies between 18 to 90 points.

**SSS.** Participants’ level of self-perceived use of sarcasm was measured by using the SSS (Ivanko et al., 2004), which was translated into Finnish. The test was a paper and pencil task with 15 items. The test items were short statements in which eight assessed general use of sarcasm and seven assessed use of sarcasm in specific situations. Participants answered the items on a 7-point scale (1 = strong disagreement, 7 = strong agreement). The test was scored by computing a sum of all answers. The test score varied between 15 and 105 points, with a higher score indicating higher self-perceived use of sarcasm.
Procedure

The procedure was similar to Experiment 1 except for the individual differences measures, which were devised after the reading task. Participants first did the reading span test (WMC), then the Need for Cognition test (NFC), and finally the SSS, which was always done last. The experiment lasted approximately 90 minutes.

Results

Data were analyzed with linear mixed-effects models as in Experiment 1. First, we fitted models with only the fixed effect of irony (which was deviation coded) and random intercepts for participants and items, which were treated as crossed random effects. The mean fixation time measures for ironic and literal texts are presented in Table 4 and the model estimates in Table 5. Irony increased the duration of the first-pass rereading and increased the probability of making a later look back to the target sentence. The look-back time to context sentences was marginally shorter in ironic than in literal texts. The effect of text type was not significant in any of the other eye movement measures (all \( t < 1 \)). Thus, the results somewhat differed from those of Experiment 1, in which an irony effect was observed also in the progressive first-pass fixation time (although the effect was marginal) and in the probability of immediate rereading during first-pass reading.

To have more statistical power, we combined the data from Experiment 1 and 2 (thus, we pooled data from 112 participants and 48 items) and carried out the analyses for the pooled data. In the pooled analysis, an irony effect was observed

<table>
<thead>
<tr>
<th>Measure</th>
<th>Literal Texts</th>
<th>Ironic Texts</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-pass progressive fixation time</td>
<td>968</td>
<td>970</td>
</tr>
<tr>
<td>Probability of first-pass rereading</td>
<td>.47</td>
<td>.50</td>
</tr>
<tr>
<td>First-pass rereading time</td>
<td>360</td>
<td>408</td>
</tr>
<tr>
<td>Probability of looking back to target</td>
<td>.37</td>
<td>.43</td>
</tr>
<tr>
<td>Look-back time</td>
<td>718</td>
<td>783</td>
</tr>
<tr>
<td>First-pass reading time on spillover region</td>
<td>1,320</td>
<td>1,297</td>
</tr>
<tr>
<td>Probability of looking back to context</td>
<td>.44</td>
<td>.45</td>
</tr>
<tr>
<td>Look-back time in context</td>
<td>889</td>
<td>781</td>
</tr>
<tr>
<td>Text memory questions</td>
<td>.89</td>
<td>.89</td>
</tr>
<tr>
<td>Inference questions</td>
<td>.93</td>
<td>.83</td>
</tr>
</tbody>
</table>
TABLE 5
Estimates of Fixed Effects, Standard Errors of the Estimates, and Corresponding \( t \) or \( z \) Values and \( p \) Values for Different Eye-Movement Measures in Experiment 2

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Effect</th>
<th>Estimate</th>
<th>SE</th>
<th>( t / z )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-pass progressive fixation time(^a)</td>
<td>Intercept</td>
<td>966</td>
<td>77</td>
<td>12.60</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.41</td>
<td>15</td>
<td>.03</td>
<td>.9692</td>
</tr>
<tr>
<td>Probability of first-pass rereading(^a)</td>
<td>Intercept</td>
<td>-.09</td>
<td>.22</td>
<td>-.43</td>
<td>.667</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.15</td>
<td>.12</td>
<td>1.31</td>
<td>.190</td>
</tr>
<tr>
<td>First-pass rereading time(^b)</td>
<td>Intercept</td>
<td>351</td>
<td>26</td>
<td>13.58</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>47</td>
<td>21</td>
<td>2.24</td>
<td>.0292</td>
</tr>
<tr>
<td>Probability of looking back to target(^a)</td>
<td>Intercept</td>
<td>-.46</td>
<td>.15</td>
<td>-3.01</td>
<td>.00260</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.32</td>
<td>.12</td>
<td>2.71</td>
<td>.00671</td>
</tr>
<tr>
<td>Look-back time(^c)</td>
<td>Intercept</td>
<td>694</td>
<td>65</td>
<td>10.74</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>58</td>
<td>64</td>
<td>.90</td>
<td>.3698</td>
</tr>
<tr>
<td>First-pass reading time on the spillover region(^d)</td>
<td>Intercept</td>
<td>1,301</td>
<td>230</td>
<td>5.65</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>-11</td>
<td>33</td>
<td>-.33</td>
<td>.7322</td>
</tr>
<tr>
<td>Probability of looking back to context(^a)</td>
<td>Intercept</td>
<td>-.24</td>
<td>.17</td>
<td>-1.38</td>
<td>.169</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>.07</td>
<td>.12</td>
<td>.57</td>
<td>.566</td>
</tr>
<tr>
<td>Look-back time for context(^e)</td>
<td>Intercept</td>
<td>763</td>
<td>96</td>
<td>7.97</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Text type</td>
<td>-127</td>
<td>68</td>
<td>-1.88</td>
<td>.0682</td>
</tr>
</tbody>
</table>

\(^a\) Based on 1,413 observations (60 participants, 24 items).
\(^b\) Based on 680 observations (60 participants, 24 items).
\(^c\) Based on 564 observations (59 participants, 24 items).
\(^d\) Based on 1,408 observations (60 participants, 24 items).
\(^e\) Based on 630 observations (60 participants, 24 items).

in the probability of immediate rereading (estimate = .34, \( SE = .09 \), \( z = 3.84 \), \( p < .001 \)), a marginally significant effect was observed in the duration of immediate rereadings (estimate = 33.98, \( SE = 18.28 \), \( t = 1.858 \), \( p = .0650 \)), and a significant effect was observed in the probability of looking back to the target sentence (estimate = .29, \( SE = .09 \), \( z = 3.44 \), \( p < .001 \)). Moreover, readers made shorter look-backs to the context when reading ironic than literal texts (estimate = -85.05, \( SE = 40.55 \), \( t = -2.098 \), \( p = .0361 \)), suggesting that looking back in text is more selectively directed to ironic parts of text when the text is ironic and distributed more evenly across the text when it is literal. In sum, the data collapsed from the two experiments demonstrated an irony effect as an increased probability and duration of first-pass rereading as well as an increased probability of looking back to the target sentence.

**Individual Differences in Online Processing of Written Irony**

The observed mean score for WMC was 30.78 (\( SD = 14.38 \)), for SSS 57.70 (\( SD = 12.42 \)), and for NFC 68.90 (\( SD = 8.52 \)). To examine individual
differences in the processing of written irony, we centered the individual differences measures (WMC, SSS, and NFC) and entered the measures as fixed effects together with the fixed effect of irony (including the interaction terms between text type and the individual differences measure) to the linear mixed effects models. The correlations between the individual differences measures were low (largest $r = .28$ for the correlation between WMC and NFC); thus, there was no indication of multicollinearity and all individual differences measures were entered to the models simultaneously. For the sake of brevity, we report below only significant or marginally significant model estimates for the individual differences measures (the effects of text type are reported above).

In the *progressive first-pass fixation time*, only the effect of WMC was significant (estimate $= -7.22$, $SE = 2.33$, $t = -3.098$, $p(MCMC) = .0006$), indicating that readers with higher WMC tended to have shorter first-pass progressive fixation times than readers with lower WMC. In the *probability of initiating an immediate rereading*, there was a marginally significant effect of WMC (estimate $= -0.02$, $SE = 0.01$, $z = -1.86$, $p = .0630$), indicating that readers with higher WMC did overall less immediate rereading than readers with lower WMC. However, this effect was qualified by a significant WMC $\times$ text type interaction (estimate $= 0.02$, $SE = 0.01$, $z = 1.99$, $p = .0465$). The nature of the interaction is illustrated in Figure 1, where a tertile split is used to divide the participants into low, medium, and high WMC groups and the observed mean rereading probabilities are presented as a function of text type (ironic vs. literal) and WMC group. As is apparent from Figure 1, high WMC readers show an increased probability of rereading ironic in comparison with literal target sentences during first-pass reading, whereas the irony effect becomes smaller as WMC decreases. Finally, there was a main effect of WMC in the *first-pass reading time of the spillover region* (estimate $= -8.97$, $SE = 3.21$, $t = -2.79$, $p(MCMC) = .0014$), indicating that the higher the WMC, the shorter the first-pass reading time. SSS or NFC did not produce any significant effects.

In sum, the analysis of individual differences in online processing of written irony indicates that of the individual differences measures included in Experiment 2, WMC had a unique contribution over and above that of the SSS and NFC to fixation times during reading of ironic sentences. However, the effects are subtle and were only observed as an increase in the probability of initiating immediate rereading of the ironic (compared with literal) target sentences.

**Text Memory and Inference Questions**

Finally, we analyzed the participants’ responses to the questions presented after reading with a 2 (text type: ironic vs. literal) $\times$ 2 (question type: memory vs.
inference) repeated-measures ANOVA. The means and standard deviations (computed for participant means) are presented in Table 4. There was a significant main effect of question type \( (F(1,59) = 11.24, p < .001, \eta^2_p = .16) \), indicating that responses were overall more accurate for the text memory than for the inference questions. A significant text type \( \times \) question type interaction \( (F(1,59) = 14.10, p < .001, \eta^2_p = .19) \) reflects the fact that there was no difference between the text types in responses to text memory questions \( (t < 1) \), whereas the mean number of correct responses to the inference questions was lower for ironic than for literal texts \( (t (59) = 5.19, p < .001) \). In other words, even though the overall accuracy in responding to the questions was relatively high, readers had more problems responding to the inference questions especially when they concerned the ironic utterances.

An interesting question is whether the individual differences measures (WMC, SSS, or NFC) explain variance in the ability to respond to the inference questions. However, correlations between the individual differences measures and the number of correct responses to inference questions after ironic texts were very low (greatest \( r = -0.176 \) for the correlation between SSS and correct responses to
inference questions), suggesting the measures used in Experiment 2 do not capture essential aspects of the ability to respond to inference questions tapping into irony comprehension.

Discussion

The results of Experiment 2 partly replicated those of Experiment 1: Irony-related increases were observed in the duration of the first-pass rereading and in the probability of making a later look-back to the target sentence. The look-back times to context sentences were marginally shorter in ironic than in literal texts. To obtain more statistical power, we combined the data from the two experiments. The results of the pooled data showed that irony increases the likelihood of initiating first-pass rereadings and look-backs to the target sentences and decreased the look-back time devoted to the previous context. These results demonstrate that irony processing does require an extra processing effort. The increased probability of initiating immediate rereadings might reflect a validation process (Singer, 2013) during which the readers validate the ironic interpretation. The increased likelihood of looking back to the ironic target sentence, on the other hand, indicates that readers strategically either recheck their interpretation or search for an alternative interpretation for the utterance. The decrease in the look-back time to the context in the ironic stories indicates that looking back in text is more focused on the target sentence in the ironic than in the literal stories. These results are in line with previous findings showing that processing of irony is mainly seen as increased rereading of the utterances (Filik & Moxey, 2010) and support the theoretical views assuming that readers have to reinterpret the meaning of ironic sentences after initial processing. Specifically, these findings are most compatible with the standard pragmatic view (Grice, 1975) and the graded salience view (Giora, 1997) of irony comprehension. However, the individual differences observed in Experiment 2 lend support to the notion that not all readers process irony in a similar way and thus support the parallel-constraint-satisfaction view (Pexman, 2008).

As for individual differences, we examined the role of SSS, WMC, and NFC in the comprehension of ironic utterances embedded in story context. We expected that individual differences in all or some of these measures would be reflected in the time course of irony processing as well as in the observed magnitude of the irony effect. The present results showed that only WMC had a unique influence on how readers process ironic vs. literal utterances: High WMC was related to an increased likelihood of initiating rereading of the ironic utterances during first-pass reading. If immediate rereading is an indicator of the validation process (Singer, 2013), as we have argued above, then these results suggest that high WMC is related to increased effort invested in validating ironic
utterances. Thus, high WMC readers seem to consider an ironic interpretation earlier, already during first-pass reading. This novel result is in line with previous research on the role of WMC in inference validation (Singer & Ritchot, 1996) and suggests that high WMC facilitates the recognition of utterances as ironic and support the idea that high WMC helps in either maintaining or activating alternative interpretations for utterances.

Against our expectations, SSS or NFC did not contribute to the processing of ironic utterances. In previous studies, high SSS has been found to facilitate irony processing (Ivanko et al., 2004). One possible reason for the difference in results might be that Ivanko and colleagues used a word-by-word paradigm, which might force readers to use strategies they do not adopt when allowed to freely inspect the text as in the present study. Another possible factor is that we used a Finnish translation of the original English version of the SSS scale, and there might be cultural differences in how people interpret scenarios as sarcastic (Dress et al., 2008). A correlation between NFC and irony comprehension has not been previously studied. The lack of correlation obtained in Experiment 2 suggests that differences in the general attitude toward cognitively demanding tasks do not explain individual variation in the processing of written irony.

GENERAL DISCUSSION

According to theories of text comprehension (e.g., Kintsch, 1998), readers try to form a coherent memory representation of the text. Ironic utterances, in which the literal meaning of the utterance is in contrast to the context in which it is presented, produce a coherence break between the surface and textbase level text representations and the situation model (Kintsch, 1998). The results of the present study demonstrate that the processing of ironies is an effortful process, at least when the ironies are not conventionalized and the story context does not prime an ironic interpretation. In terms of the Construction-Integration model (Kintsch, 1998), the present results may be taken to suggest that solving an incoherence caused by irony between the surface and textbase level representations on one hand and the situation model on the other hand results in extra cognitive effort. The present results also support the notion that readers validate the interpretation of an utterance as soon as they encounter it (Singer, 2013). Sometimes, however, the validation process fails, and this disrupts the updating of the situation model. The present results showing poorer performance in the inference questions after ironic than literal stories indicate that despite the extra processing effort invested in ironic stories readers do not always come to understand the ironic meaning of the utterance.

The subtle individual differences related to WMC in the processing of ironic utterances indicate that present theories of irony comprehension should also take into account the comprehender’s cognitive abilities. At present, only the parallel-
constraint-satisfaction model (Pexman, 2008) is equipped to explain individual differences in the irony comprehension. Comprehending irony is a relatively complex cognitive task: It requires that the reader is capable of inferring the mental state and the intentions of a protagonist (the speaker/writer), which might mean the reader has to adopt the perspective of another person (e.g., Shamay-Tsoory, Tomer, & Aharon-Perez, 2005). In future research, the role of general cognitive abilities (e.g., WMC) and the contribution of social skills (e.g., empathy) in the comprehension and processing of irony should be investigated in more detail.

Finally, the present experiments demonstrate the utility of eye tracking in studying the comprehension of written irony (see also Filik & Moxey, 2010). The eye-tracking methodology provides detailed information about the time course of text processing without posing extra demands (e.g., pressing a button to proceed in the text) on the reader. The present experiments demonstrate that methodological choices contribute to the observed findings, which might have significant theoretical implications. This is a point that the advocates of the different theoretical views of irony comprehension should keep in mind.

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