Examining the role of context in written sarcasm comprehension: Evidence from eye-tracking during reading

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Abstract

This paper addresses a current theoretical debate between modular and interactive accounts of sarcasm processing, by investigating the role of context (specifically, knowing that a character has been sarcastic before) in the comprehension of a sarcastic remark. An eye-tracking experiment was conducted where participants were asked to read texts that introduced a character as being either sarcastic or not, and ended in either a literal or an unfamiliar sarcastic remark. The results indicated that when the character was previously literal, a subsequent sarcastic remark was more difficult to process than its literal counterpart. However, when the context was supportive of the sarcastic interpretation (i.e., the character was known to be sarcastic), subsequent sarcastic remarks were as easy to read as literal equivalents, which would support the predictions of interactive accounts. Importantly, this effect was not preceded by a main effect of literality, which constitutes evidence against the predictions of modular accounts.

Keywords: sarcasm; irony; language comprehension; figurative language; eye-tracking.

Introduction

Using sarcasm carries the risk that the reader might misinterpret the message as being literal. For example, imagine that you text your friend Maya about your idea to go and see a spoken word performance together, and she texts you a reply saying, "*Your idea is great*". If Maya was being sarcastic but you fail to interpret the message as such, that will lead to a disruption in your communication. However, it can be very difficult to interpret the message as sarcastic unless you already know, for example, that Maya dislikes spoken word performances and so she cannot literally mean that your idea is great. In other words, having some contextual information might help you to correctly interpret a sarcastic message.

Theories of sarcasm processing

A central topic of investigation in the psycholinguistics literature has been to examine the influence of context on language processing at various levels (i.e., syntactic, semantic, pragmatic). These investigations have typically been couched in terms of contrasting the predictions of modular versus interactive accounts of language processing (see e.g., Degen & Tanenhaus, 2019, for recent relevant discussion). This modular versus interactive debate also extends to the current domain of investigation, in that there is disagreement amongst theorists over the role played by context in sarcasm processing.

Modular accounts, such as the standard pragmatic model (Grice, 1975) or the graded salience hypothesis (Giora, 1997; 2003), propose that the initial stages of sarcasm comprehension are not affected by contextual information. The standard pragmatic model claims that when a sarcastic remark is encountered, the literal meaning is accessed first, and is later replaced by the sarcastic meaning when the reader realises that the literal meaning does not fit with the context. Therefore, it predicts that literal comments should be processed faster (i.e., read more quickly) than sarcastic ones irrespective of contextual factors, due to the extra steps involved in sarcasm processing.

The graded salience hypothesis (recently subsumed by the defaultness hypothesis, e.g., Giora, Drucker, Fein, & Mendelson, 2015) claims that the salient meaning (or default interpretation) of a comment will be accessed (or constructed) initially, independently of context. If the sarcastic remark is familiar (often used as sarcastic, and hence the sarcastic meaning is readily available to the reader even outside of context, e.g., "*That's just great!*"), the sarcastic meaning can be accessed directly, and should be processed as quickly as a literal equivalent. In contrast, for unfamiliar comments (i.e., comments that are rarely, if ever, used sarcastically), the graded salience hypothesis makes the same prediction as the standard pragmatic model. Even a context which strongly supports the non-salient (e.g., sarcastic) meaning cannot prevent the initial activation of the salient (literal) meaning (Giora, 1997).

In contrast, interactive accounts such as the echoic mention theory (Sperber & Wilson, 1981), direct access view (Gibbs, 1986), implicit display theory (Utsumi, 2000), or constraint satisfaction model (Pexman, 2008), assign a key role to contextual factors (see also Gibbs, 1979; and Ortony, Schallert, Reynolds, & Antos, 1978, for earlier, related work on context effects). These accounts predict that a sarcastic comment could be correctly interpreted as soon as it is encountered if it echoes an explicit contextual expectation (echoic mention theory), a discrepancy between expectation and reality is contained in the context (direct access view), or the context constitutes an ironic environment (the speaker has an unmet expectation that the listener is aware of, and the speaker has a negative emotional attitude towards the incongruity between expectation and reality – implicit display theory). The constraint satisfaction model is currently a framework that allows for many different and unspecified contextual factors to act as cues for sarcasm.

The influence of context on sarcasm processing

In the first study to show context effects on reading times, Gibbs (1986, Experiment 1) reported *shorter* sentence reading times for ironic comments (e.g., "You are a fine friend")

compared to non-ironic controls (e.g., “You are a bad friend”). Additionally, when reading times for sentences with the same surface form (“You are a fine friend”) were compared in ironic (somebody *not* being a good friend) and non-ironic (somebody being a good friend) contexts, there were no differences - findings taken in support of the direct access model. However, simple non-ironic acknowledgements like “You are a good friend” were read more quickly than ironic comments (see Giora, 1995, for further discussion and refutation of Gibbs’ results).

More recently, in a series of eye-tracking and reading experiments, we have aimed to systematically investigate various different contextual cues that have been proposed to have a key influence. Specifically, in investigating the predictions made by the implicit display theory, we found that making the speaker’s (unmet) expectation explicit in the context did not reduce or eliminate processing difficulty for sarcastic utterances compared to literal controls, thus providing no support for this theory (Ţurcan & Filik, 2016). In contrast, in a subsequent study testing the predictions of the echoic mention theory, we found that when sarcastic comments echoed an explicit contextual antecedent, this *did* make processing of sarcastic utterances as fast as literal equivalents, thus providing some evidence that context can influence processing (Ţurcan & Filik, 2017). Evidently, it seems to be the case that while some contextual factors have the predicted influence on processing, others do not.

A further contextual factor that has received a lot of interest, but has led to mixed results, is the influence of speaker characteristics on processing and interpretation. Speaker characteristics (such as talker-specificity) have recently been shown to influence language comprehension in a number of domains, such as the interpretation of quantifiers (Yildrim, Degen, Tanenhaus, & Jaeger, 2016), referring expressions (Pogue, Kurumada, & Tanenhaus, 2016), and in making stereotype-based inferences (e.g., van Berkum, van den Brink, Tesink, Kos, & Hagoort, 2008). Some studies have also examined the influence of speaker properties,

such as speaker occupation, on irony comprehension (see Katz, Blasko, & Kazmerski, 2006, for an overview). For instance, Katz and Pexman (1997) presented readers with ambiguous statements such as *Children are precious gems,* which can either be interpreted metaphorically (i.e., that children are valuable) or as ironic metaphors (in which they are not). They found that when the comments were stated as being uttered by someone from a "high-irony" profession (such as a comedian) they were judged as being more sarcastic and mocking than when uttered by a speaker from a "high-metaphor" profession (e.g., a priest). Pexman and Olineck (2002) later reported a similar finding for statements that were ambiguous between a literal and ironic interpretation (e.g., *You are a wonderful/terrible friend*), when other contextual cues were minimal. In a follow-up of the Katz and Pexman (1997) study, using word-by-word self-paced reading, Pexman, Ferretti, and Katz (2000) found that mention of speaker occupation also influenced reading times for statements that were ambiguous between a metaphorical and ironic metaphor reading. However, they did not directly assess whether speaker occupation eliminated processing difficulty for ironic utterances versus non-ironic counterparts.

Another speaker-related factor that has received some attention in the literature is whether the context introduces a character as typically sarcastic (i.e., the character has used sarcasm before), or not. For example, in a self-paced reading task, Giora et al. (2007, Experiment 1) presented participants with dialogues between two characters, one of which uttered a sarcastic remark midway through the dialogue, followed by another literal or sarcastic remark. They found that even when a sarcastic character was introduced into the story, a subsequent sarcastic remark uttered by that character was still read more slowly than a literal remark. Later, Fein, Yeari, and Giora (2015) slightly altered Giora et al.'s materials to ensure that participants clearly understood hat the mid-context utterance was sarcastic. They did this by including a cue in the dialogue (e.g., *Sagit (derisively): You're a really*

active guy). They found that even when a sarcastic character was more explicitly introduced into the story, subsequent sarcastic comments were still slower to read than literal ones. Their conclusion was that even when the context creates an expectation for sarcasm by introducing a sarcastic character, the activation of the literal meaning cannot be overridden, and hence the processing of a sarcastic remark is still more difficult than that of a literal remark, as predicted by modular accounts.

In an event-related potential (ERP) study, Regel, Coulson, and Gunter (2010) asked participants to read scenarios in order to get used to the communicative style of two characters – in the first half of the experiment one character used sarcasm 70% of the time and the other 30% of the time, while in the second half both characters uttered equal proportions of sarcastic and literal comments. Results showed that learning that a character was sarcastic modulated the neurocognitive processes underlying both early and late stages of sarcasm comprehension. Specifically, both P200 and P600 amplitudes were larger for sarcastic than literal comments when made by non-sarcastic speakers, but they were equal for literal and sarcastic comments made by sarcastic speakers. These findings were considered evidence for interactive accounts.

Thus, previous studies have led to conflicting results. Giora et al. and Fein et al. found no effect of context on sarcasm processing, but it should be noted that their dependent measure was the total reading time of the entire target utterance. In the absence of more fine-grained measures, it is possible to miss contextual effects if they were only present during certain stages of comprehension or on certain regions of the target utterance. Regel et al. did find that context can have an effect on sarcasm comprehension. However, their study design allowed participants to accumulate a wealth of information regarding the communicative style of the speakers in their stimuli, since there were only two (one established as highly ironic, and one as mostly literal). It is of interest to assess whether the same effect can be

observed in a design which introduces new interlocutors within each trial (for which contextual information would then need to be assessed and utilised more rapidly). Finally, in all three studies participants read the stimuli sentence-by-sentence or word-by-word. They therefore did not have the opportunity to read as they would normally (e.g., to return to text that they have previously read), which may be important for sarcasm comprehension (see Olkoniemi, Johander, & Kaakinen, 2019, for recent discussion).

The current study

The current study was designed to further investigate whether contextual cues can affect the processing of a subsequent sarcastic remark. Participants will have their eye movements monitored whilst they read literal or sarcastic target sentences that are contained in dialogues in which the speaker of the target utterance is previously introduced as being sarcastic or not (see Table 1). Thus, we are following the approach of Fein et al. (2015), but using a methodology which allows for a more fine-grained analysis of the reading process. Stimulus presentation will be natural, with one entire experimental scenario being presented at once on the screen, allowing participants to read and re-read as they would normally. A number of different reading time measures will be calculated, allowing us to examine in some detail how readers process sarcastic language. Specifically, calculating *first-pass reading time* will allow is to assess whether readers experience immediate difficulty on encountering a region of text, by summing the duration of initial fixations within a region. *Regression path reading time* will allow us to examine whether readers have gone back to re-read earlier portions of text in order to overcome this processing difficulty, by adding any additional time spent re-reading the region (or earlier regions) before the reader moves on in the text. *Total reading time* will indicate overall processing difficulty by summing the total time spent fixating a region (including re-reading). Finally, we will further bolster the contextual manipulation employed by Fein et al. (2015), in that we will state more explicitly that the

character is being sarcastic in the sarcasm biasing context condition (i.e., will state *said sarcastically*, rather than *said derisively*).

Predictions

Modular accounts would predict a main effect of literality prior to any interaction with context, since for unfamiliar sarcastic comments (which will be utilised here) the (salient) literal meaning of the comment should always be accessed first, regardless of context. There are a large number of ways in which such a pattern of effects could manifest in the eye movement record. To illustrate but a few - a main effect of literality could occur, for example, in early measures of reading time (e.g., first-pass reading times) on the critical word which disambiguates the target comment as being literal or sarcastic. A relatively delayed interaction with context may then be observed, for example: in later measures of reading time on the critical disambiguating word itself (e.g., regression path or total reading times); in measures which could be indicative of re-reading of previous parts of the text (such as total reading times on the pre-critical region), or in any measure of reading time on the post-critical region of text. Regardless of the precise pattern of effects that might be observed, the key prediction is that a main effect of literality should arise *before* any interaction with context.

In contrast, interactive accounts would predict *no main effect* of literality before an interaction between literality and context is observed. Specifically, there should be no difference in reading times between a literal and a sarcastic remark when the character is known to be sarcastic, or, potentially, there should be shorter reading times for sarcastic remarks. In contrast, there should be longer reading times for sarcasm when a character is previously literal, as in this case the context does not induce an expectation for sarcasm.

Method

Participants

Thirty-two native English speakers from the University of Nottingham took part (M_{age} = 22.9 years old, *SD* = 6.9 years old, 27 females). They were not diagnosed with any reading difficulties, had normal or corrected vision, and received course credit for their participation. The study was approved by the School of Psychology ethics committee (ref: 245).

Materials and design

Thirty-two experimental stimuli were created, each containing eight sentences describing a conversation between two characters (see Table 1 for an example). The first two sentences described the context in which the scenario was set (e.g., *Laura and Henry had been living together for over a year now. Laura asked Henry to clean the kitchen whilst she was at work.*). The remaining scenario was presented as a dialogue between the two characters. The third sentence was a line uttered by one of the characters, and was the same across all conditions (e.g., *Laura: Did you clean the kitchen like I asked?*).

The fourth sentence was different depending on whether one of the characters was introduced as literal or as sarcastic. For the example in Table 1, in the condition where Laura was introduced as a literal character, the fourth sentence was: *Henry: I cleaned the living room and dining room first, and was just about to start on the kitchen.*, to which Laura's response (fifth sentence) was a literal one, *Laura: Well that was nice of you!*. In the condition where Laura was introduced as a sarcastic character, the fourth sentence was: *Henry: Not quite. I put out the cleaning spray and some cloths, and was about to start.*, to which Laura's response was a sarcastic one: *Laura said sarcastically: Well that was nice of you!*.

The sixth sentence differed between the literal and sarcastic target conditions. When the sixth sentence was: *Henry: I'll clean the kitchen now whilst you have a bath.*, the subsequent target utterance was designed to be interpreted literally, *Laura: I knew you were*

gallant!. On the other hand, when the sixth utterance was: *Henry: Anyway, you can do it now that you're back.*, the same target utterance was to be interpreted sarcastically. All sarcastic utterances were unfamiliar (see below for familiarity pre-test). Finally, the eighth sentence wrapped up the scenario (e.g., *Henry: Do you want to have some takeaway tonight?*). Thirteen of the experimental stimuli contained a male speaker, while 19 contained a female speaker.

Thus, the experiment consisted of a 2 literality (literal target remark vs. sarcastic target remark) x 2 context (literal character vs. sarcastic character) design, with both factors being within-subjects and within-items. Thirty-five filler items accompanied the experimental scenarios. They had the same structure as the experimental items, but only contained literal utterances.

As each scenario had four versions, one for each experimental condition, four stimulus presentation files were created, each containing only one version of each scenario, and a total of eight experimental items for each condition. This was to ensure that participants were exposed to each scenario in only one experimental condition. Each participant was presented with one stimulus file. The order in which the scenarios were presented within each stimulus file was randomised for each participant.

< insert Table 1 here >

Familiarity pre-test. A questionnaire containing 147 target utterances in isolation was given to nine native English speakers (M_{age} = 26.8 years old, *SD* = 8.1 years old, five females). Their task was to rate on a scale from 1 (unfamiliar) to 8 (familiar) how familiar they were with the sarcastic meaning of each phrase. Thirty-two remarks were selected, with a mean familiarity score of 2.8, *SEM* = 0.12 (see Appendix for full set of target utterances). A

one-sample *t*-test showed that there was a significant difference between the familiarity scores of the selected target utterances and the middle of the scale, $t(31) = 14.1$, $p < 0.001$, Cohen's $d = 2.50$.

Interpretation pre-test. In order to assess whether the target comments were likely to be interpreted as intended, we created four questionnaires containing all 32 experimental scenarios (with each scenario appearing in only one condition per questionnaire, presented in random order). After reading each scenario, participants were asked to rate how likely they thought it was that the character truly held the belief in the test sentence, on a scale from 1 (very unlikely) to 8 (very likely). If comments were interpreted sarcastically, we expected participants to rate them towards the bottom of the scale, as in those cases the characters do not hold the beliefs expressed in the test sentences. A total of 31 participants (17 female, age range from 20 to 31 years old, M_{age} = 24 years old, SD_{age} = 2 years and 5 months) filled in the questionnaires.

A one-sample *t*-test comparing the mean of the sarcastic ratings with the middle of the scale yielded significant results, indicating that the sarcastic materials were rated significantly lower, $t(30) = 13.33$, $p < 0.001$, Cohen's $d = 2.39$. Thus, when the final comment was sarcastic, readers did understand that the expressed belief was unlikely to be true. Furthermore, a paired-samples *t*-test showed that the sarcastic condition resulted in significantly lower ratings that the literal condition ($M_{sarcastic} = 2.3$, $SEM_{sarcastic} = 0.13$; $M_{literal} = 5.7$, $SEM_{literal} = 0.13$), $t(30) = 16.98$, $p < 0.001$, Cohen's $d = 3.05$, as expected. Taken together, we believe that these results allow us to confidently assume that the target comments used in this study were generally interpreted as intended.

Procedure

Eye movements were recorded via an SR Research EyeLink 1000 eye-tracker that sampled eye position every millisecond. Materials were displayed on a computer screen

56cm from participants' eyes. Participants were instructed to read as they would normally for comprehension. Each trial consisted of one scenario, presented in its entirety on the screen, with two blank lines between each line of text. Participants pressed the right-shoulder button on a hand-held controller to progress to the next trial.

After 25% of trials, a yes/no comprehension question was asked (see Table 1). The average correct response rate of 89.3% (*SD* = 7.31) indicated that participants were reading for comprehension.

Results

The scenarios had three analysis regions (see Table 1). The critical region was the word that disambiguated the target utterance as being either sarcastic or literal. Following Țurcan and Filik (2016; 2017), the pre-critical region comprised the *two* words that preceded the disambiguating word. This was to avoid excessive data losses due to the single word immediately prior to the critical region often being very short (such as *is*, *of*, *so* etc.) and therefore likely to be skipped. The post-critical region was the three words that followed the disambiguating word. Since this region always contained the name of the character who was speaking, we reasoned that by the end of the passage (where the target comment occurred), participants might no longer fixate the character name (since it is repeated throughout). Therefore, we included the character name plus two content words in the post-critical region (we included two rather than one, as again, some of these words might be very short words such as *I*, *do*, *my*, *we*, etc.).

Fixations under 80ms were incorporated into larger adjacent fixations within one character, and fixations under 40ms that were not within three characters of another fixation were deleted, as were fixations over 1200ms. Trials that had zero first-pass reading times for two consecutive regions (where regions were defined as a whole sentence in the context, the pre-critical, critical, and post-critical regions) were eliminated (discarded trials accounted for

5.4% of the data). Three measures of reading behaviour are reported. *First-pass reading time (fp)* is the sum of all fixations in a region from first entering it until leaving it either via its left or right boundary. *Regression path reading time (rp)* is the sum of all fixations on a region and on preceding regions from first entering the region to first going past it, that is, leaving it via its right boundary. *Total reading time (tt)* is the sum of all fixations in a region, including fixations made when re-reading the region. When reading times were zero for a particular region, the relevant point was excluded from the analyses, and means were calculated from the remaining data points in the design cell (see Table 2 for percentage of data removed following this procedure).

Data analysis was performed in R (R Core Team, 2013) using linear mixed effects modeling (*lme4* package). We report the regression coefficients (*b*), *t*-values (*t*), *p*-values (*p*), 95% confidence intervals, and the random effects structures with the variance and standard deviation (*SD*), where the lmerTest package was used to compute the *p*-values.

< insert Table 2 here >

The next step was to establish the appropriate random effects structure for each analysis. We started by fitting the maximal model to the data, as recommended by Barr, Levy, Scheepers, and Tily (2013). We included *literality* (literal target remark vs. sarcastic target remark) and *context* (literal character vs. sarcastic character) as fixed factors in the model. For *literality* and *context* the fixed effects were coded using treatment contrasts: literal target remark = 0, sarcastic target remark = 1, literal character = 0, sarcastic character = 1. If the maximal model failed to converge, the random effects structure had to be simplified in order to obtain convergence. This was done by progressively removing one random

component at a time - the one that explained the least amount of variance in the previous nonconverging model.

Once the random effects structure had been established, the final step was to perform a series of likelihood ratio tests comparing the fit of models with progressively simpler fixed-effects structures in order to reach the best model fit for our data[1]. For a more detailed discussion of the data analysis procedure, please see Ţurcan and Filik (2016). See Table 3 for the models that had the best fit for our data and the values of their fixed-effects parameters and random structures.

< insert Table 3 here >

The pre-critical region. There were no effects in any reading time measures (see Figure 1 – Pre-critical region).

The critical region. There were no effects in first-pass reading times on the critical region (see Figure 1 - Critical region - fp). However, an interaction was observed between the literality of the target comment and whether the character was known to be literal or sarcastic in the context, in both regression path and total reading times (see Figures 2 and 3 - Critical region - rp and tt).

When a character had previously been literal in the context, there were shorter regression path reading times for literal target utterances than sarcastic utterances (rp: b = -58.9, t = 2.7, p = .01, 2.5% CI = -101.4, 97.5% CI = -16.4). This effect did not reach significance in total reading times (tt: b = -32.1, t = 1.9, p = .06, 2.5% CI = -64.6, 97.5% CI = 0.3). When a character had previously been sarcastic, there was no difference in reading times between literal and sarcastic target utterances (rp: b = 39.6, t = 1.8, p = .08, 2.5% CI = -3.8, 97.5% CI = 83.1; tt: b = 10.5, t = 0.6, p = .53, 2.5% CI = -21.8, 97.5% CI = 42.8). This

suggests that when the context provided a cue for sarcasm (i.e., knowing that a character is sarcastic), this cue facilitated the comprehension of subsequent sarcastic remarks, such that they could be processed as easily as literal remarks.

The post-critical region. There were no effects in any reading time measures (see Figure 1 - Post-critical region).

<Insert Figures 1, 2, and 3 here>

Discussion

The experiment described in this paper contrasted the predictions of modular and interactive accounts of sarcasm comprehension by examining whether a contextual factor, specifically, knowing that a character has been sarcastic before, can influence the processing of subsequent sarcastic remarks.

Summary of findings

An influence of context was observed on the way in which sarcastic utterances were processed in both regression path and total reading times, on the word that disambiguated the target utterance as being intended literally or sarcastically. Specifically, when the character had previously uttered a literal comment, then the target utterance resulted in longer reading times when it was intended sarcastically than when it was intended literally. In contrast, when the character had been introduced in the context as being sarcastic, readers no longer experienced processing difficulty for a sarcastic target utterance compared to its literal counterpart.

Integration with previous empirical findings

The finding of longer reading times for a sarcastic comment uttered in a literal-biasing context would concur with previous research showing disruption to eye movements during

the reading of sarcastic utterances (Au-Yeung, Kaakinen, Liversedge, & Benson, 2015; Filik et al., 2014; Filik, Howman, Ralph-Nearman, & Giora, 2018; Filik & Moxey, 2010; Kaakinen, Olkoniemi, Kinnari, & Hyönä, 2014; Olkoniemi et al., 2019; Olkoniemi, Ranta, & Kaakinen, 2016; Olkoniemi, Strömberg, & Kaakinen, 2019; Țurcan & Filik, 2016; 2017). Observing effects in measures of reading time that include some aspect of re-reading (i.e., regression path and total times) suggests that readers needed extra time to re-analyse utterances as being sarcastic.

The finding that this processing difficulty was eliminated when the sarcastic comment was uttered in a supportive context is not consistent with the previous work of Giora et al. (2007, Experiment 1), who found that sarcastic target sentences took longer to read than literal controls, regardless of whether the character had previously made a sarcastic comment in the context. However, in their study, the character was not explicitly introduced in the context as being sarcastic, so it is possible that participants may not have picked up on the fact that the character was being sarcastic before (i.e., the contextual cue may not have been strong enough). In the related study of Fein et al. (2015), the authors *did* include a more explicit cue (e.g. *derisively*) regarding the character being sarcastic in the context, and in this case still found longer reading times for sarcastic than literal target sentences. It is still possible that their cue was not as explicit as the one used in the present experiment (i.e., *said sarcastically*), which might explain why we found a contextual effect while Fein et al. (2015) did not. It must be noted that by adopting the stronger manipulation of Fein et al. (2015), in which the attitude of the speaker is explicitly mentioned, we cannot say for certain whether it is the fact that a speaker has been previously sarcastic, or that sarcasm has been mentioned in the context (or some combination of the two) that leads to such a strong context effect. Further research is required to clarify this issue.

The current data are more consistent with the findings of Regel et al. (2010), who showed that knowledge of a character's sarcastic style facilitated sarcasm comprehension. However, the current data extend this finding to a different methodology, importantly, one in which participants can read naturally. In addition, in Regel et al.'s study, speaker effects were observed when the speaker was sarcastic across a majority of experiments trials (70%). In the current study, we show that it is sufficient for the speaker to have made one previous sarcastic comment in order for processing difficulty for subsequent sarcasm to be eliminated. This suggests a powerful role for certain contextual cues in the processing of sarcasm.

Implications for theories of sarcasm processing

In relation to the predictions of the various theories of sarcasm comprehension, it is crucial to note that in no reading measure or analysis region was a literality main effect found, that is, there was no evidence that literal comments were generally processed faster than sarcastic comments regardless of the contextual factor. This provides evidence against modular accounts, which would predict that literal (Grice, 1975) or salient (Giora, 1997; 2003) interpretations cannot be blocked by the context. This would concur with the broad rejection of modular accounts across other domains such as syntactic processing (see e.g., Altmann, 1998, for discussion).

Interactive accounts on the other hand could potentially explain both the absence of a main effect of literality and the effect of context on sarcasm comprehension. Interactive accounts all agree that embedding sarcastic utterances in contexts that support a sarcastic interpretation should facilitate the processing of that utterance when compared to a literal equivalent. However, they do not all agree on the specific factors that make a context supportive of a sarcastic interpretation. We now consider whether the various different interactive accounts mentioned in the Introduction can explain the current findings. In general, our results fit well with direct access type accounts (e.g., Gibbs, 1986; 2002), which

would predict that the ironic interpretation of a comment can be constructed directly, without first considering the literal interpretation, given a sufficiently supportive context.

The current results also may be consistent with the predictions of implicit display theory (Utsumi, 2000) if we consider the previous mention of a sarcastic speaker to be contributing to an "ironic environment", although the theory itself does not make this specific prediction with regards to a sarcastic speaker. However, in previous eye-tracking studies (Țurcan & Filik, 2016) we found that making the speaker's expectation explicit in the context, which is stated as a key contributor to an ironic environment, did not have the expected effect on the reading times of subsequent sarcastic remarks, suggesting that implicit display theory cannot account for the full range of eye-tracking data.

In relation to echoic mention theory, following this account we would have no reason to predict differences between cases in which a sarcastic speaker was or was not explicitly mentioned in the context, as neither case involves echoing a previous utterance. However, previous eye-tracking experiments have demonstrated that echoing an explicit contextual antecedent, as proposed by the echoic mention theory, *did* make processing sarcastic utterances as fast as literal equivalents (Țurcan & Filik, 2017).

Taken together, our current results and those of our previous eye-tracking studies provide evidence against the modular accounts' prediction that contextual factors cannot prevent the initial delay in sarcasm processing when compared to literal equivalents, but also that not all contextual factors have the effects predicted by specific interactive accounts.

Conclusions

Thus, there is no current theory that can easily explain all of the findings mentioned above. Although at first sight one might conclude that the constraint-satisfaction model could account for the results, it is important to remember that this model as it is currently instantiated (e.g., Pexman, 2008) is very general and it does not make clear, testable

predictions. In order to achieve the furtherment of a constraint-satisfaction model to account for sarcasm processing, researchers arguably first need to identify the relevant constraints that can influence processing. Some progress towards this has been attained by the growing body of empirical literature which has investigated a wealth of factors that might influence the processing and interpretation of sarcastic utterances. A tangible advancement could be made if these results were utilised to develop a more formal computational model from which explicit testable predictions can be made. This approach would concur with work in the broader experimental pragmatics literature which, although still in the very early stages, has seen recent steps towards the development of constraint-satisfaction models of certain aspects of pragmatic processing, such as scalar implicature (Degen & Tanenhaus, 2015).

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Figure captions

Figure 1. Mean reading times for the pre-critical (top row), critical (middle row), and post-critical (bottom row) regions. Error bars represent ±1 *SEM*.

Figure 2: Interaction between context and literality for regression path reading times in the critical region. Error bars represent ±1 *SEM*.

Figure 3: Interaction between context and literality for total reading times in the critical region. Error bars represent ±1 *SEM*.

Footnote

[1]We also investigated the effect of presentation order, by adding it as a fixed effect to the models (in a similar procedure to Olkoniemi et al., 2019). There was no significant interaction between trial order and context or literality of the target comment, however there was a main effect of trial order on total reading time on the post-critical region, such that reading times in the second half of the experiment were 45.7ms shorter than in the first half of the experiment. The main effect suggests that participants re-read less as they proceeded through the experiment, potentially due to them getting used to the task. However, the lack of an interaction means that trial order did not interfere with the effects of context, which were the focus of this paper.

Appendix

Full list of target utterances

1. Your humour is great!
2. My kind of food!
3. I knew you were gallant!
4. Your look is very chic!
5. That looks tasty!
6. Your suggestion is stirring!
7. Your help is always guaranteed!
8. Your outfit is professional!
9. Your work is progressing fast!
10. You're doing things in so much haste!
11. That was masterful!
12. You're equipped so well!
13. That's very courteous of you!
14. Your help is priceless!

15. Your assistance is invaluable!

16. You prepared thoroughly.

17. This car is what we needed!

18. Your suggestion was great!

19. Your chivalry is unmatched.

20. I like your willingness!

21. Your idea is so adventurous!

22. I appreciate your alertness!

23. Our talk was impeccable!

24. Your assistance was useful!

25. That was systematic!

26. Our office is well-ordered!

27. Your choice is exhilarating!

28. Your help was priceless!

29. You got me impatient!

30. Your food is delicious!

31. You packed them great!

32. This lunch is great!

Table 1. Example material		
Literality of target remark	Literality of character	Example material
Literal target remark	Literal character	Laura and Henry had been living together for over a year now. Laura asked Henry to clean the kitchen whilst she was at work. Laura: Did you clean the kitchen like I asked? Henry: I cleaned the living room and dining room first, and was just about to start on the kitchen. Laura: Well that was nice of you! Henry: I'll clean the kitchen now whilst you have a bath. Laura: I knew/ you were pre-critical region/ gallant! critical region/ Henry: Do you post-critical region/ want to have some takeaway tonight?

	Sarcastic character	Laura and Henry had been living together for over a year now. Laura asked Henry to clean the kitchen whilst she was at work. Laura: Did you clean the kitchen like I asked? Henry: Not quite. I put out the cleaning spray and some cloths, and was about to start. Laura said sarcastically: Well that was nice of you! Henry: I'll clean the kitchen now whilst you have a bath. Laura: I knew/ you were pre-critical region/ gallant! critical region/ Henry: Do you post-critical region/ want to have some takeaway tonight?

Sarcastic target remark	Literal character	Laura and Henry had been living together for over a year now. Laura asked Henry to clean the kitchen whilst she was at work. Laura: Did you clean the kitchen like I asked? Henry: I cleaned the living room and dining room first, and was just about to start on the kitchen. Laura: Well that was nice of you! Henry: Anyway, you can do it now that you're back. Laura: I knew/ you were pre-critical region/ gallant! critical region/ Henry: Do you post-critical region/ want to have some takeaway tonight?
	Sarcastic character	Laura and Henry had been living together for over a year now. Laura asked Henry to clean the kitchen whilst she was at work.

		Laura: Did you clean the kitchen like I asked? Henry: Not quite. I put out the cleaning spray and some cloths, and was about to start. Laura said sarcastically: Well that was nice of you! Henry: Anyway, you can do it now that you're back. Laura: I knew/ you were pre-critical region/ gallant! critical region/ Henry: Do you post-critical region/ want to have some takeaway tonight?
Yes/No comprehension question	Did Henry offer to clean the kitchen for Laura whilst she was at work?	

Table 2. Summary of 0-ms reading time removal		
Analysis region	Reading measure	% of missing data
pre-critical	fp	20.5
	rp	20.5
	tt	3
critical	fp	10.6
	rp	10.4
	tt	9.2
post-critical	fp	21.2
	rp	21.2
	tt	6.9

Table 3. Best fitting models and fixed-effects parameters and random structures.

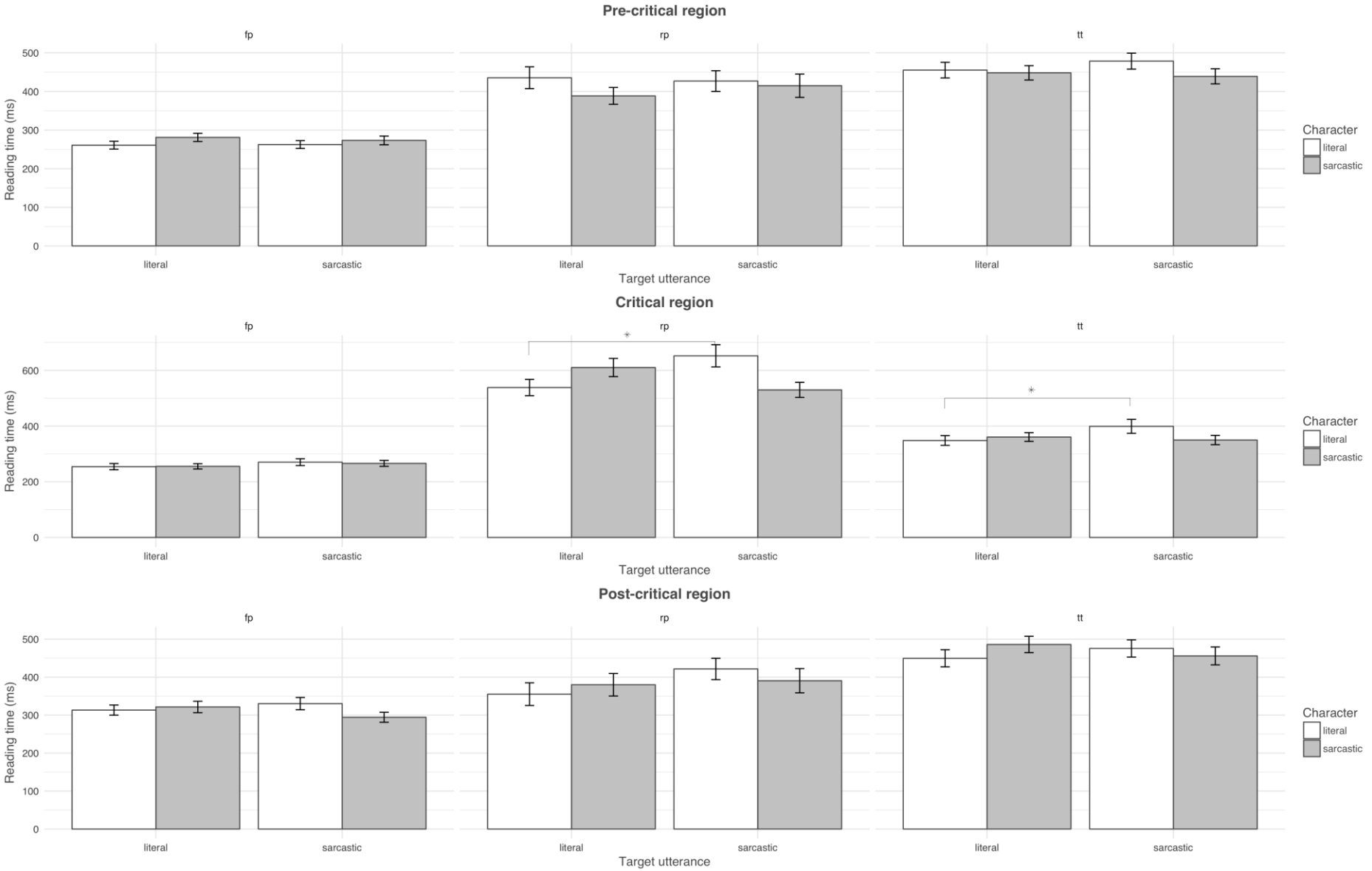
Analysis region	Reading measure	Model	Fixed effects	b	t	95% CI		Random effects	Variance	sd
						2.5%	97.5%			
pre-critical	fp	~ 1 + (1|subject) + (1|item)	(Intercept)	268.3	25.1***	246.7	289.8	Subject (Intercept) Item (Intercept)	2280.6 560.3	47.8 23.7
	rp	~ 1 + (1 + context*literality|subject) + (1|item)	(Intercept)	411.6	16.8***	361.2	462.0	Subject (Intercept) Subject (Context) Subject (Literality) Subject (Context*Literality) Item (Intercept)	19418.0 7703.0 6069.0 26350.0 3750.0	139.4 87.8 77.9 162.3 61.2

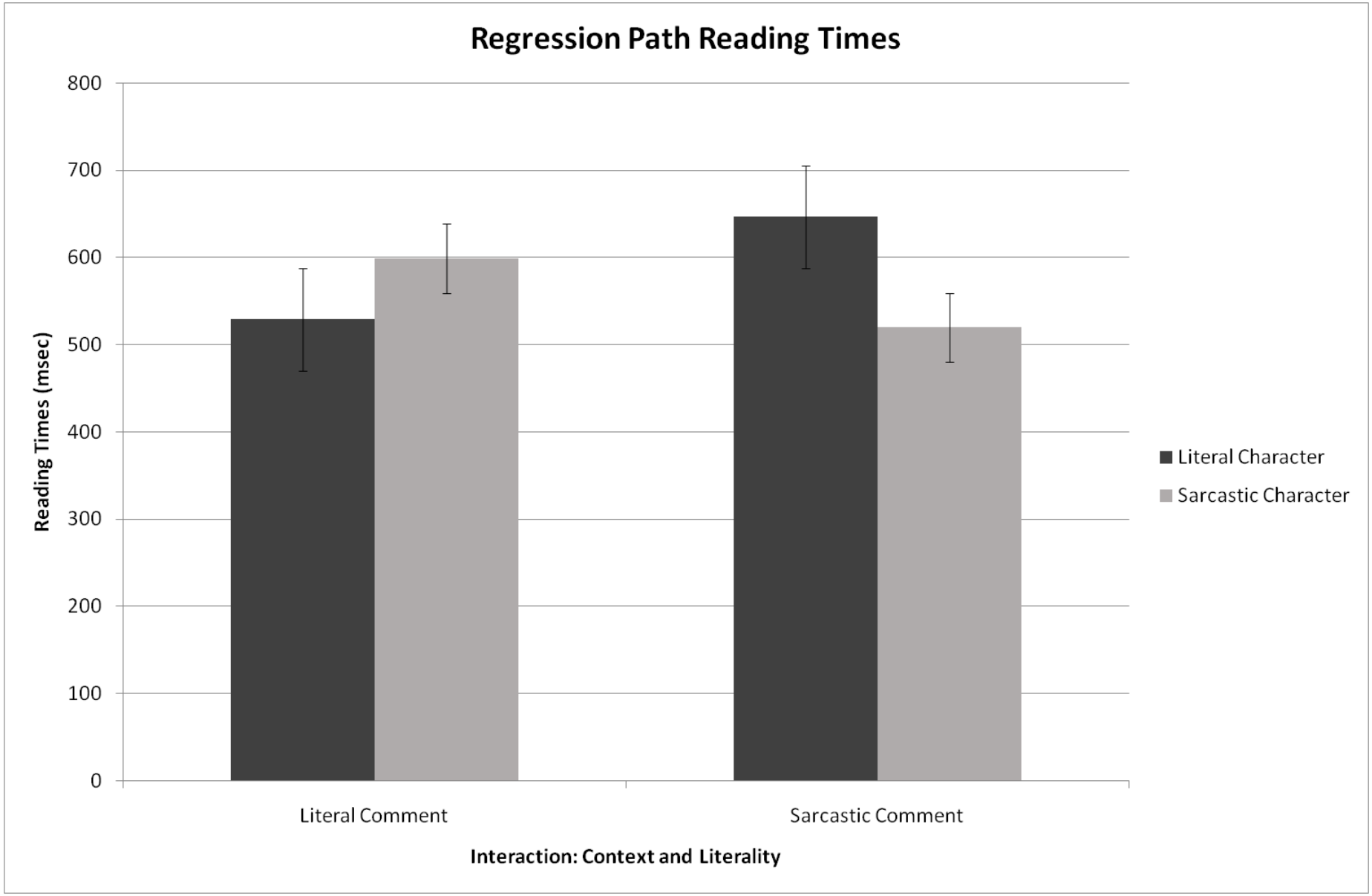
	tt	~ 1 + (1 + literality|subject) + (1 + literality|item)	(Intercept)	434.6	21.3***	393.8	475.4	Subject (Intercept) Subject (Literality) Item (Intercept) Item (Literality)	7793.7 1.7 1856.7 2971.6	88.3 1.3 43.1 54.5
critical	fp	~ 1 + (1 + context*literality|subject) + (1 + context*literality|item)	(Intercept)	257	21.7***	232.6	281.4	Subject (Intercept) Subject (Context) Subject (Literality) Subject (Context*Literality) Item (Intercept) Item (Context) Item (Literality) Item (Context*Literality)	7885.2 3036.5 1400.5 1401.7 2813.3 259.8 2993.5 5705.2	88.8 55.1 37.4 37.4 53.0 16.1 54.7 75.5

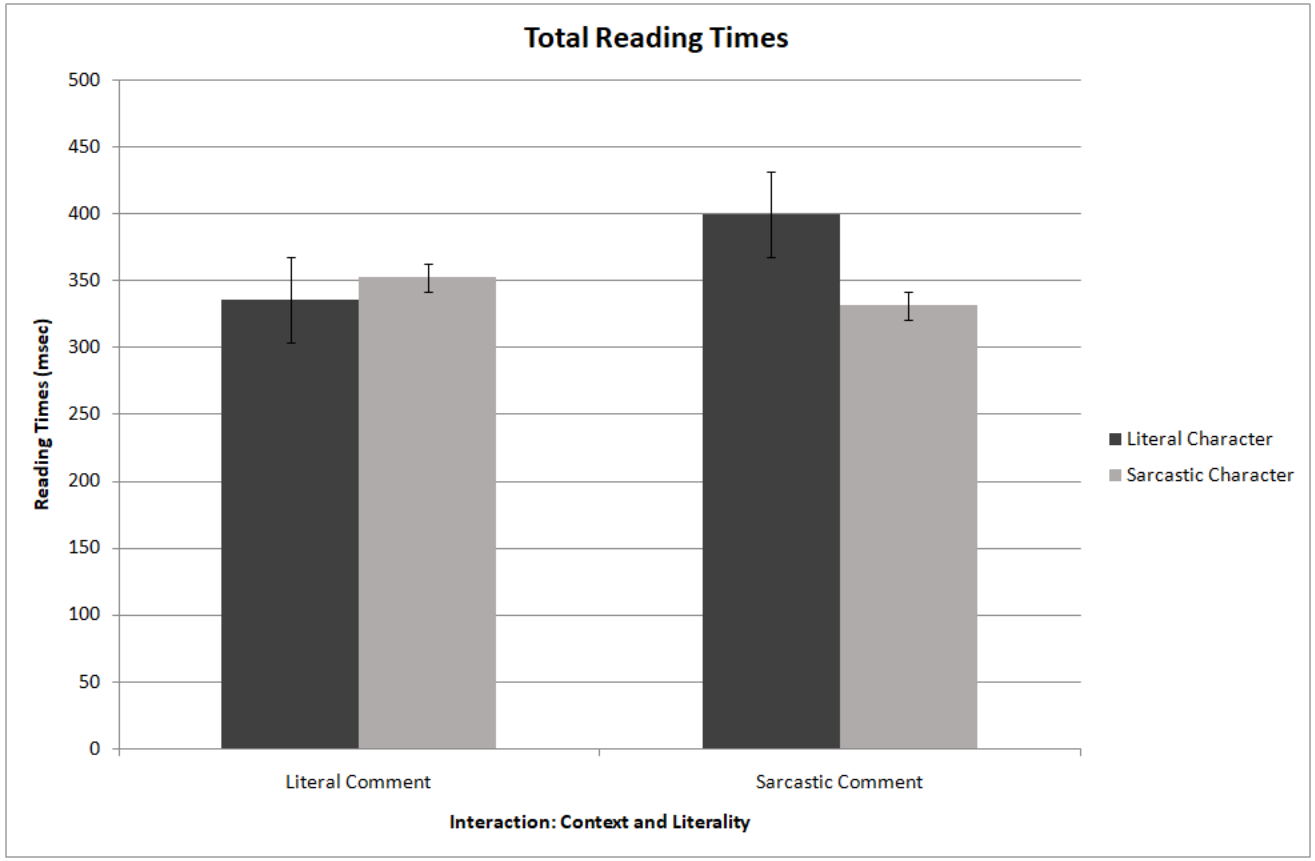
	rp	~ context*literality + (1 + context*literality|subject) + (1 + context*literality|item)	(Intercept)	528.6	10.8***	433.0	624.3	Subject (Intercept)	32680.8	180.8
			context	70.2	1.7*	-10.9	151.1	Subject (Context)	2699.1	52.0
			literality	118	2.8***	34.3	201.6	Subject (Literality)	1561.2	39.5
			context * literality	-197.1	-3.3***	-314.2	-79.9	Subject (Context*Literality)	6607.4	81.3
								Item (Intercept)	16692.4	129.2
								Item (Context)	32.4	66.5
								Item (Literality)	4419.4	59.9
								Item (Context*Literality)	3589.0	416.0
	tt	~ context*literality + (1 + literality|subject) + (1 + literality|item)	(Intercept)	335.5	13.8***	287.8	383.2	Subject (Intercept)	0.0	0.0
			context	17.3	0.7	-31.4	65.9	Subject (Literality)	11005.0	104.9
			literality	64.2	2.0*	-0.3	128.7	Item (Intercept)	8820.0	93.9
			context * literality	-85.2	-2.4**	-154.3	-16.1	Item (Literality)	3575.0	59.8

post-critical	fp	~ 1 + (1|subject) + (1 + context*literality|item)	(Intercept)	301.7	14.7***	259.9	343.2	Subject (Intercept) Item (Intercept) Item (Context) Item (Literality) Item (Context*Literality)	11400.7 1374.9 517.8 1384.5 2851.6	106.8 37.1 22.8 37.2 53.4
	rp	~ 1 + (1 + context*literality|subject) + (1 + context|item)	(Intercept)	384.7	13.3***	327.8	441.6	Subject (Intercept) Subject (Context) Subject (Literality) Subject (Context*Literality) Item (Intercept) Item (Context)	22589.4 11708.5 581.1 20655.6 0.0 17282.6	150.3 108.2 24.1 143.7 0.0 131.5

	tt	~ 1 + (1 + context*literality|subject) + (1 + context*literality|item)	(Intercept)	454.8	14.6***	393.8	515.9	Subject (Intercept) Subject (Context) Subject (Literality) Subject (Context*Literality) Item (Intercept) Item (Context) Item (Literality) Item (Context*Literality)	146896.0 36277.0 22695.0 13790. 4536.0 3437.0 3716.0 2850.0	383.3 190.5 150.7 117.4 67.4 58.6 61.0 53.4
Notes. *** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$; + $p \leq .10$										


Pre-critical region
fp
rp
tt
Reading time (ms)
0
100
200
300
400
500
literal
sarcastic
Target utterance
Character
literal
sarcastic
Critical region
fp
rp
tt
Reading time (ms)
0
200
400
600
literal
sarcastic
Target utterance
Character
literal
sarcastic
Post-critical region
fp
rp
tt
Reading time (ms)
0
100
200
300
400
500
literal
sarcastic
Target utterance
Character
literal
sarcastic


Regression Path Reading Times
800
700
600
500
400
300
200
100
0
Reading Times (msec)
Literal Character
Sarcastic Character
Literal Comment
Sarcastic Comment
Interaction: Context and Literality


Total Reading Times
500
450
400
350
300
250
200
150
100
50
0
Reading Times (msec)
Literal Comment
Sarcastic Comment
Interaction: Context and Literality
Literal Character
Sarcastic Character