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# Context, facial expression and prosody in irony processing

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## Abstract

While incongruence with the background context is a powerful cue for irony, in spoken conversation ironic utterances often bear non-contextual cues, such as marked tone of voice and/or facial expression. In Experiment 1, we show that ironic prosody and facial expression can be correctly discriminated as such in a categorization task, even though the boundaries between ironic and non-ironic cues are somewhat fuzzy. However, an act-out task (Experiments 2 & 3) reveals that prosody and facial expression are considerably less reliable cues for irony comprehension than contextual incongruence. Reaction time and eye-tracking data indicate that these non-contextual cues

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entail a trade-off between accuracy and processing speed. These results suggest that interpreters privilege frugal, albeit less reliable pragmatic heuristics over costlier, but more reliable, contextual processing.

*Keywords:* irony; figurative language; prosody; facial expression; context; eye-tracking

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## 1 Introduction

2 Imagine that, as you announce that you will not attend a crisis meeting  
3 because of a party, your boss replies ‘I love your sense of responsibility!’.  
4 Most likely, the incongruity of her comment with the conversational context  
5 – broadly understood as shared background knowledge or beliefs (in the clas-  
6 sic sense of [Stalnaker, 2002](#)) – will (correctly) prompt you to interpret it as  
7 ironic. While such ironic utterances pervade our daily conversations, irony is  
8 notoriously difficult to define in precise terms (e.g. [Gibbs, 2000](#); [Gibbs & Col-](#)  
9 [ston, 2012](#), p. 52) and surfaces under many different guises (such as sarcasm,  
10 jocularly, hyperbole, rhetorical question, and understatement). Neverthe-  
11 less, in one sense or another, all ironically intended messages deliberately  
12 mismatch the utterance literal content.<sup>1</sup>

13 Incongruence with the background context, of the kind just illustrated,  
14 is a powerful cue for irony ([Gerrig & Goldvarg, 2000](#); [Kreuz & Link, 2002](#)).  
15 However, there are indications that a statement may still be interpreted as  
16 ironic in the absence of such contextual incongruity, provided that other cues

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<sup>1</sup> Of course, contextual incongruence does not necessarily boil down to manifest falsity; for instance, hyperbolic, but nevertheless literally true statements may be ironic ([Sperber & Wilson, 1981](#); [Kreuz & Roberts, 1995](#)).

17 are available (e.g. [Kowatch et al., 2013](#); [Jacob et al., 2016](#)). In particular,  
18 spoken ironic utterances are often associated with a specific facial expression  
19 and a distinctive prosody (e.g. [Attardo et al., 2003](#); [Rankin et al., 2009](#)). To  
20 the extent that such cues to irony do not directly rely on background context,  
21 in what follows we will dub them ‘non-contextual’, as opposed to contextual  
22 incongruity.

23 The precise role non-contextual cues play in irony processing remains  
24 ill understood. On one hand, there is some evidence that a global ironic  
25 prosody can be correctly discriminated from a non-ironic one ([Bryant &  
26 Fox Tree, 2005](#)), provided that the statement is uttered in a familiar language  
27 ([Cheang & Pell, 2011](#)). And, in fact, many experimental designs implicitly  
28 presuppose that ironic prosody is efficient, as they use a distinctive prosody to  
29 contrast between ironic and literal stimuli (e.g. [Chevallier et al., 2011](#); [Colich  
30 et al., 2012](#); [Kowatch et al., 2013](#)). On the other hand, [Bryant & Fox Tree  
31 \(2005\)](#) report that a prosodic contour that is successfully discriminated as  
32 ironic is also perceptually associated with other dimensions, such as anger  
33 or inquisitiveness. Furthermore, the perception of a given prosodic contour  
34 as ironic or not may be influenced by the contextual availability of an ironic  
35 interpretation ([Voyer et al., 2016](#)).

36 We submit that while ironic tone of voice and/or ironic facial expression  
37 may be correctly *discriminated*, these cues are not necessarily efficient in a  
38 genuine process of irony *comprehension*. Arguably, successful social interac-  
39 tions do not reduce to tagging statements as literal or not (viz. discrimina-  
40 tion), but require the identification of the speaker’s discourse goals, and the  
41 selection of an appropriate reaction (viz. comprehension; see [Kreuz 2000](#)).

42 Studies in brain-damaged patients suggest a dissociation between these two  
43 processes: some patients fail to understand the speaker’s intent when contex-  
44 tual and prosody cues are available, even though they are able to identify the  
45 tone of voice as sarcastic (McDonald, 2000; McDonald & Pearce, 1996). Yet,  
46 irony processing is usually investigated through tasks in which participants  
47 have to judge as quickly as possible if statements are ironic or not, thus mea-  
48 suring only the discrimination component. For instance, Bryant & Fox Tree  
49 (2002) found that participants successfully discriminate ironic vs. non-ironic  
50 utterances based on their prosody.<sup>2</sup> However, making decisions in a binary,  
51 forced-choice task is very different from interpreting a message in the same  
52 way as would its actual addressee. The precise role of prosody within irony  
53 comprehension is further blurred by the fact that Bryant & Fox Tree (2002)  
54 found context to be a more powerful cue for ironic judgements than prosody.

55 A notable exception to such metalinguistic decision paradigms is the  
56 study by Kowatch et al. (2013), who designed an innovative ‘shopping task’  
57 that positions participants as active interpreters. In this experimental design,  
58 a puppet faces food items (e.g. an apple and an orange) and utters literal or  
59 ironic statements about what it wants to buy (e.g. ‘I just love apples’). Only  
60 the puppet’s tone of voice allows to disentangle ironic criticisms (e.g. ‘I just  
61 love apples’), literal criticisms (e.g. ‘I just hate apples’) and literal praise  
62 (e.g. ‘I just love oranges’). Participants are asked to put in a shopping cart  
63 the food item the puppet really wants. In this way, participants’ response

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<sup>2</sup> There are many other experimental studies that approach irony exclusively through discrimination; see, for instance, Kreuz & Roberts (1995); Climie & Pexman (2008); Epley et al. (2004); Chevallier et al. (2011); Colich et al. (2012).

mirrors their interpretation of the discourse goals of the speaker. The results of Kowatch et al. (2013) display an interesting asymmetry between accuracy and reaction time. The rate of correct responses for ironic items is low (less than 60%), and significantly so relative to literal items. At the same time, the authors report no difference in processing time or in frequencies of first looks to the correct object for ironic and literal criticisms. It could be the case, then, that while ironic prosody and/or facial expression are not very reliable for accurately grasping an ironic communicative intention, they still prompt a rapid, cognitively shallow attribution of ironic intentions to the speaker.

Importantly, Kowatch et al. (2013) did not compare ironic prosody relative to the role of context, so it is unclear whether interpreters still use prosody when context is available, and if yes, whether non-contextual cues merely complement context-based processing or whether they may take precedence over it. There is ample evidence that mastery of irony presupposes complex mental-state attribution skills (e.g. Akimoto et al., 2012; Bryant, 2012; Spotorno & Noveck, 2014). Such mentalising processes require inferring the speaker's intention by assessing the utterance content against the background context. Some theorists hold that any type of pragmatic processing involves complex, context-based inferences about the speaker's communicative intentions (Sperber & Wilson, 2002). Consistently with this idea, in 5- to 7-year-old children, it is the capacity to attribute multilayered mental states, and not ironic prosody, that predicts correct discrimination between irony and white lies (Wimmer & Leekam, 1991; see also Filippova & Astington, 2010).

89        However, it is also plausible that conversationally experienced interpreters  
90 sometimes rely more on salient non-contextual cues than on context. For in-  
91 stance, [Deliens et al. \(2017\)](#) recently found that in the presence of salient  
92 ironic prosody, participants do not engage in context-based perspective-  
93 shifting to gauge the sarcastic nature of a message. According to the parallel-  
94 constraint-satisfaction account ([Katz, 2005](#); [Pexman, 2008](#)), all cues are pro-  
95 cessed in parallel and activate a certain – possibly ironic – interpretation.  
96 However, as acknowledged by [Pexman \(2008\)](#) herself, this model does not  
97 currently provide any indication as to the relative weight of different cues.  
98 A more radical idea, to which we subscribe, is that the presence of salient,  
99 albeit perhaps less reliable, non-contextual cues prompts interpreters to dis-  
100 regard costlier contextual processing. This hypothesis is consistent with the  
101 Direct Access view (e.g. [Gibbs, 2002](#)), which predicts that interpreters do  
102 not always need to analyse literal meaning in full to form a hypothesis about  
103 the meaning communicated by the speaker. It is also in line with a model  
104 of pragmatics according to which interpreters are driven by considerations  
105 of cognitive economy, and do not necessarily engage in extensive context-  
106 driven reasoning about speaker’s intentions ([Kissine, 2016](#); see also [Ferreira](#)  
107 [& Patson, 2007](#)).

108        By contrast, Giora’s Graded Salience theory ([Giora, 2003](#); [Giora et al.,](#)  
109 [2015](#)) holds that, unless the sentence form bears a conventional or by-default  
110 association with irony,<sup>3</sup> utterance literal, compositional meaning will nec-

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<sup>3</sup> So far, evidence for such by-default ironic meanings, outside conventionally ironic constructions, is limited to negative statements of the form ‘X is not the most Y’ ([Giora et al., 2015](#)).

111 essarily be activated first before being rejected in favor of a contextually  
112 computed ironic interpretation. On different grounds, authors like [Sperber](#)  
113 [& Wilson \(2002\)](#), who hold that any pragmatic processing involves context-  
114 based inference of speaker’s intentions, would also have to predict that non-  
115 contextual cues can supplement, but not replace context in irony compre-  
116 hension.

117     Summing up, two related research questions clearly emerge from the cur-  
118 rent state of the art: one about the reliability of non-contextual cues, and  
119 the other about the relative processing roles of contextual and non-contextual  
120 cues. In [Experiment 1](#) of this paper we assess the discrimination of ironic  
121 prosody relative to neutral prosody, as well as to positive or negative literal  
122 prosody; we also test, in the exact same way, the discriminability of ironic  
123 facial expression. (While the discrimination of ironic prosody has been previ-  
124 ously investigated, to the best of our knowledge no such evidence is available  
125 for ironic facial expression.) In [Experiments 2 and 3](#) we assess how the same  
126 prosody and facial cues, as well as contextual information impact irony com-  
127 prehension, using an act-out task inspired by [Kowatch et al. \(2013\)](#). Our  
128 Hypothesis 1 is that in a categorization task ironic prosody and ironic facial  
129 expression should allow correct discrimination of ironic items. In line with the  
130 model put forward by [Kissine \(2016\)](#), as well as with the Direct Access view  
131 ([Gibbs, 2002](#)), we predict that in the act-out tasks of [Experiments 2 and 3](#)  
132 the presence of salient – albeit potentially less reliable – non-contextual cues  
133 should prompt interpreters to bypass costlier contextual processing. That  
134 is, our Hypothesis 2 is that ironic prosody and facial expression are privi-  
135 leged in irony comprehension at the expense of costlier, but more accurate



136 assessment of the utterance literal content relative to the context. Accord-  
137 ingly, one should expect non-contextual cues to be associated with faster  
138 responses; furthermore, if, as we predict, the processing of ironic prosody or  
139 facial expression does not supplement context-based assessment of the com-  
140 positional meaning, non-contextual cues should not entail any accuracy gain  
141 relative to contextual incongruence.

142 Our [Hypothesis 2](#) may also be seen as one possible implementation of  
143 the parallel-constraint-satisfaction model of irony interpretation ([Katz, 2005](#);  
144 [Pexman, 2008](#)). As we already mentioned, this model predicts that contex-  
145 tual and non-contextual cues are processed in parallel. If parallel processing  
146 of all cues must be completed before the outputs are weighted and the fi-  
147 nal interpretation reached, then, contrary to our predictions, the presence of  
148 non-contextual cues along with contextual incongruence should lead to longer  
149 reaction times. However, the parallel-constraint-satisfaction model could also  
150 assign greater weight to non-contextual cues, in such a way that costlier pro-  
151 cesses terminate before completion in the presence of salient ironic prosody  
152 or facial expression. In that case, this model would be entirely consistent  
153 with our predictions.

154 By contrast, the predictions generated by our [Hypothesis 2](#) are incom-  
155 patible with accounts that posit obligatory processing of contextual cues in  
156 irony derivation. According to Relevance theory ([Sperber & Wilson, 2002](#))  
157 or the Graded Salience theory ([Giora, 2003](#)), ironic interpretation necessarily  
158 involves the assessment of the utterance content against the background con-  
159 text.<sup>4</sup> If so, non-contextual cues would merely add a supplementary source of

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<sup>4</sup> Again, with the possible proviso concerning conventional or by-default ironic meanings

160 evidence for (or against) ironic interpretation, the integration of which should  
161 lead to increased response times – especially if these cues are not entirely  
162 congruent with context-based processing. Furthermore, if non-contextual  
163 cues supplement obligatory context-based processing, accuracy levels should  
164 increase when ironic prosody or facial expression combine with contextual  
165 incongruence.

## 166 **Experimental stimuli**

167 All experiments reported in this paper use (part of) thirty-six videos (and  
168 two practice trials videos) in French, in which two individuals discuss two  
169 items placed on the table in front of them. Each video can be subdivided  
170 in (*a*) a context segment, (*b*) a labeling and question segment, (*c*) a pause  
171 segment and (*d*) the target utterance. First, the character (A) at the right  
172 of the screen mentions her/his knowledge about the second character’s (B)  
173 preferences regarding the two items placed on the table (e.g. ‘George, I  
174 know that you like chemistry and that you really hate physics. But reading  
175 a physics book could be interesting.’). This part contains contextual back-  
176 ground information useful for detecting potential sarcasm. Second, A labels  
177 the two items on the table to ensure participants could identify them (e.g.  
178 ‘Here is a chemistry book and here is a physics book.’) and then asks B  
179 if s/he wants one of the two items (e.g. ‘Would you like the physics book  
180 as a gift, now?’). Third, a black screen appears and participants are asked  
181 to press the space bar to hear B’s reply. Fourth, a video appears with B’s

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(Giora et al., 2015); see footnote 3.

182 reply, viz. the target (e.g. ‘No, you know how much I hate physics!’). In  
 183 Experiments 2 and 3 the video freezes until the participant selects the item  
 184 she believes B really wants. Clicking the right mouse button corresponds to  
 185 the object at the right of the screen and clicking the left mouse button to the  
 186 object at the left of the screen. Time course of a video stimulus is illustrated  
 187 in Figure 1.

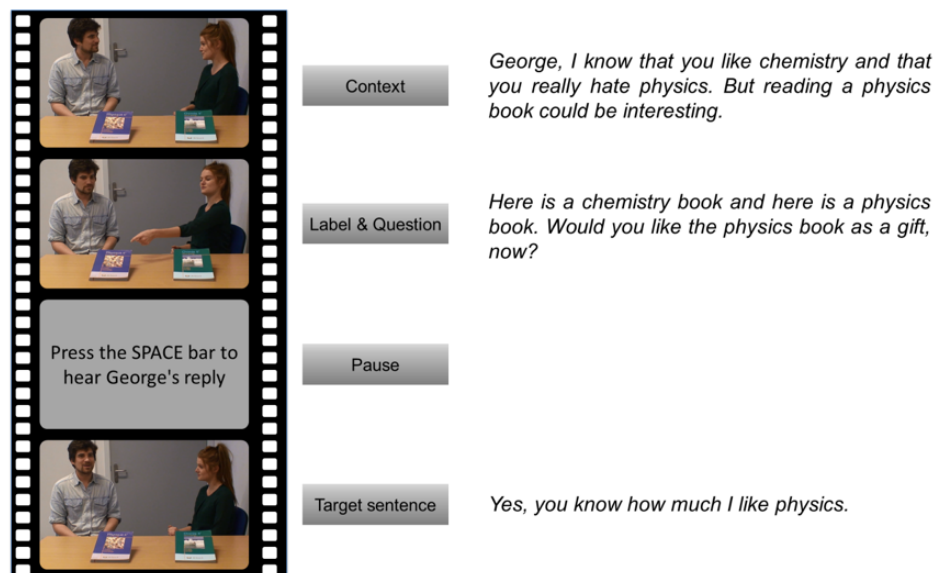


Figure 1: Time course of a full stimulus

188 The thirty-six videos are drawn on twelve scenarios (see Figure 2). There  
 189 are three versions of each scenario based on the meaning of the target: an  
 190 *Ironic*, a *Literal Yes* and a *Literal No* version (see Table 1 for a translated  
 191 example of the three versions of a scenario). The meaning of the target was  
 192 manipulated by modifying the contextual information (B’s preferences are  
 193 congruent vs. incongruent with B’s reply) and the beginning of the target

194 (‘Yes, you know how much I like X’ vs. ‘No, you know how much I hate X’).  
 195 Three professional actors formed three pairs (actor 1 and 2, actor 1 and 3,  
 196 actor 2 and 3). Each actor performed in 12 videos, 6 as individual A and 6  
 as individual B.

	LITERAL NO	IRONIC	LITERAL YES
<i>Context</i>	George, I know that you like drink- ing milk and that you really don’t like drinking tea for breakfast. But some kinds of tea are really nice.		George, I know that you like tea for breakfast and you have said this to me many times.
<i>Label</i> <i>Q</i> <i>Question</i>	George, here is a glass of milk and here is a cup of green tea. Would you like the cup of green tea with your break- fast, now?		
<i>Target</i>	No, you know how much I hate tea for breakfast!	Yes, you know how much I like tea for breakfast!	

Table 1: Example of three versions (Literal No, Ironiic and Literal Yes) of a scenario

197

198 Each video vignette was assigned to one of 6 conditions defined in func-  
 199 tion of the presence or the absence of specific cues: Context only, Prosody  
 200 only, Context & Prosody, Context & Facial expression, Prosody & Facial  
 201 expression, and Context, Prosody & Facial expression. In conditions where  
 202 contextual cues were not available, the context segment of the video was  
 203 removed. In the conditions where the prosodic cues were not available, the  
 204 actor was asked to utter the target sentence on a monotonous tone of voice.  
 205 By contrast, when prosody cues were present, the actor was instructed to  
 206 utter the target sentence with the corresponding prosody (literal positive for

207 Literal Yes items, literal negative for Literal No items and ironic for Ironic  
 208 items). The same applies to facial expression cues. Each target is thus as-  
 209 sociated with one of the four following prosody contours and one of four  
 210 following facial expressions: *Ironic*, *Literal Yes*, *Literal No* and *Neutral*.

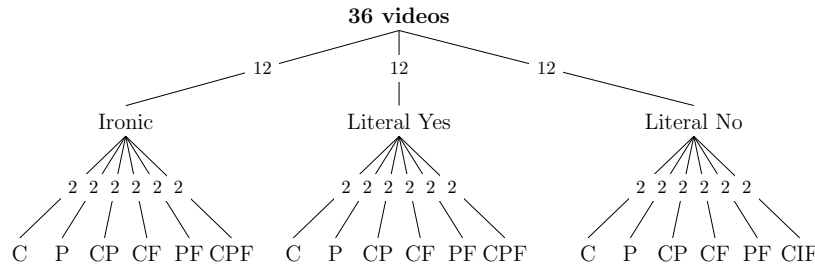


Figure 2: Assignment of the 36 experimental videos across conditions. Contextual cue (C), Prosody cue (P), Facial expression cue (F)

211 Recall that our overarching objective is to disentangle potentially differ-  
 212 ential roles of contextual and non-contextual cues in irony processing. In  
 213 order to do so, one should avoid using stimuli whose ironic character is in-  
 214 herently difficult to grasp, as this would entail a markedly low accuracy on a  
 215 sub-set of items. This is why, as in [Kowatch et al. \(2013\)](#), our ironic stimuli  
 216 always consist of negative meanings associated with literally positive sen-  
 217 tences (‘Yes’ sentences; see [Table 1](#)); utterances of the opposite valence —  
 218 literally negative sentences with a positive ironic meaning — are much less  
 219 canonical forms of irony, and have been found to be particularly difficult to  
 220 grasp (e.g. [Kreuz & Link, 2002](#); [Climie & Pexman, 2008](#); [Filippova & Astington, 2010](#)). For a similar reason, no item is associated with Facial expression  
 221 as the only cue towards the (non-)ironic meaning. A marked facial expres-  
 222 sion with no context support and combined with a neutral prosody would be  
 223

224 too an unnatural and ambiguous cue, and would increase the risk of chance  
225 performance.

226 It is possible that the most salient acoustic correlates of ironic prosody are  
227 not intrinsic, but rather relative to the surrounding discourse (Bryant, 2010).  
228 However, ironic prosody has also been reported to have inherent acoustic  
229 correlates at the level of fundamental frequency (F0), intensity and delivery  
230 rate (e.g. Rockwell, 2000; Bryant, 2010; Anolli et al., 2000; Løevenbruck et al.,  
231 2013). For all target segments, F0 (in Hz, every 3 ms), intensity (in dB, every  
232 11 ms) and syllable duration (in ms) were measured using Praat (Boersma &  
233 Weenink, 2017). A linear regression implemented in the lmer package (Bates  
234 et al., 2015) in R (R Core Team, 2016) reveals that only mean intensity  
235 predicts the type of prosody ( $F(3, 32) = 6.84$ ;  $p = 0.001$ ; all other  $ps > 0.3$ ).  
236 Because the first word of the target is always a monosyllabic *yes* (*oui*) or  
237 *no* (*non*), it made sense to assess whether ironic prosody is reflected in its  
238 acoustic properties. For first syllables of target utterances, we found an effect  
239 of prosody type on the mean intensity ( $F(3, 32) = 4.472$ ,  $p = 0.001$ ) and of  
240 syllable length ( $F(3, 32) = 8.586$ ,  $p < 0.001$ ). As can be seen from Table 2,  
241 the ironic prosody of our stimuli is associated with a significantly higher mean  
242 intensity in the whole sentence and in the first syllable in comparison with  
243 all other prosody types, and with significantly longer first syllable relative to  
244 Neutral prosody.

245 In an attempt to objectify differences in facial expressions, five compo-  
246 nents have been analyzed during the target sentence: eyes, mouth, eyebrows,  
247 head and upper body. If there was at least one movement in a component  
248 (e.g., raising eyebrows), it was scored as 1; if the component remained still,

	Mean intensity (sentence)	Mean intensity (first syllable)	Length (first syllable)
Intercept (Ironic)	73.48*** (0.79)	71.54*** (0.96)	553.50*** (41.34)
Literal Yes	-3.35** (1.11)	-4.22** (1.36)	-106.37 (58.47)
Literal No	-3.68** (1.11)	-0.31 (1.36)	-102.50 (58.47)
Neutral	-4.43*** (1.01)	-2.64* (1.24)	-261.33*** (53.38)
R <sup>2</sup>	0.39	0.30	0.45
Adj. R <sup>2</sup>	0.33	0.23	0.39
Num. obs.	36	36	36
F statistic	6.84	4.47	8.59

\*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$

Table 2: Coefficients (and standard errors) of linear regressions of mean intensity (whole sentence and first syllable) and of syllable length (first syllable) on prosody Type

249 it was scored as 0. A total facial expression score (ranging from 0 to 5) for  
250 an item is then the sum of the five component scores. Actors have been  
251 consistent in their way to display emotions. For neutral facial expressions  
252 ( $n = 18$ ), they all kept still ( $m = 0.28, sd = 0.57$ ). For marked facial ex-  
253 pressions (ironic or literal,  $n = 18$ ), actors were all using combinations of  
254 different movements ( $m = 2.94, sd = 1.26$ ). An ordinal regression imple-  
255 mented in the `clm` function from the `ordinal` package (Christensen, 2015) in  
256 R (R Core Team, 2016) reveals a significant effect of video category (Marked  
257 vs. Neutral facial expression;  $z = 34.98, p < 0.001$ ) with a higher number  
258 of component movements in the Marked facial expression condition, but no  
259 effect of Type (Ironic vs. Literal Yes vs. Literal No;  $p > 0.19$ ).

260 Further qualitative inspection reveals a difference between Marked facial

expressions across Types. In the Literal Yes condition, actors look enthusiastic or happy: they display sincere static smile (mouth and eyes), as well as little and brief eyebrows upward movements. In the Literal No condition, actors look upset or angry: they visibly accentuate plosive consonants, shrug and slightly project their torsos, display accentuated and long eyebrow raising and frowning, produce head negation movements at the syllable rhythm, as well as increased blinking, half-closure and a wide-open eyes. In the Irony condition actors look sarcastic: they produce many wide eyebrow upward movements, eyebrows are also often arched, they display huge false frozen smiles ending in a cold expression, sway their body, and produce many repeated wide and slow head movements.

## Experiment 1

The aim of Experiment 1 is to assess whether prosody or facial expressions can be correctly discriminated as ironic against a sincere or neutral counterpart. To this end, we isolated these cues from target segments of our material, and ran a first experiment where participants had to rate these isolated cues from sincere to ironic on a 7-point Likert scale.

### *Participants*

One hundred thirty-nine volunteers participated in this first experiment. Data from 12 participants were discarded from the analyses because they were not French native speakers ( $N=9$ ) or due to a problem with the network connection during the task ( $N=3$ ). The remaining 127 volunteers (63 males) ranged in age from 16 to 53 years ( $m = 26.68$ ,  $sd = 7.50$ ).



## 284 Procedure

285 To investigate the discrimination of ironic prosody and facial expression,  
286 we isolated the targets of the 36 videos described in the [previous section](#),  
287 and next, split them into a stand-alone audio file and a video file with muted  
288 sound. The resulting audio and video files all belong to one of the following  
289 four types: *Literal Yes*, *Literal No*, *Neutral* and *Ironic*. The 36 audio files  
290 and 36 video files were presented in the same randomised order across par-  
291 ticipants, using the online survey application [LimeSurvey](#), with implemented  
292 audio and video players. The experiment was composed of two parts: the  
293 scoring of the facial expression and the scoring of the prosody. One group of  
294 participants (Group *Prosody-Facial Expression*:  $N=66$ , 43 males, age 16-49  
295 years,  $m = 26.06$ ,  $sd = 7.04$ ) scored first the prosody and then the facial  
296 expression, while the second group performed the task in the opposite or-  
297 der (Group *Facial Expression-Prosody*:  $N= 61$ , 20 males, age 19-53 years,  
298  $m = 27.34$ ,  $sd = 7.98$ ). In the prosody part, participants were asked to listen  
299 to each sound excerpt and to rate the speaker’s tone of voice on a 7-point  
300 Likert scale ranging from (1)-‘completely sincere’ to (7)-‘completely ironic’.  
301 They were instructed to focus on the prosody independently from the con-  
302 tent of the sentence. In the facial expression part, participants were asked  
303 to watch each video and to rate the (left side of the screen) speaker’s facial  
304 expression on the same 7-point Likert scale. We pointed out that the sound  
305 of the videos was removed to allow them to focus on the speaker’s facial  
306 expression.

## 307 *Results*

308 Participants' ratings of prosody and facial expression were analysed with  
309 cumulative link mixed models, using the `clmm` function from the `ordinal`  
310 package in R (Christensen, 2015). Here and in Experiments 2 and 3, the  
311 significance of the fixed effects was assessed by performing likelihood ratio  
312 tests in which a model containing the fixed effect is compared to another  
313 model without it, but with an otherwise identical structure (Baayen et al.,  
314 2008). Post-hoc comparisons of least square-means, with Tukey adjustment  
315 for multiple comparisons and Satterthwaite method for estimating degrees of  
316 freedom, were performed using the `lsmeans` package (Lenth, 2016).

317 *Prosody (audio data)*. Figure 3 displays irony rating on a (1-7) Likert scale  
318 per type of prosody. Cumulative link multilevel logit regressions with by-  
319 subject random intercepts and random slopes for the Type factor (Ironic  
320 vs. Literal Yes vs. Literal No vs. Neutral) revealed a significant effect  
321 of Type ( $\chi^2(3) = 233.18$ ,  $p < 0.001$ ), but not of Group (Prosody-Facial  
322 Expression vs. Facial Expression-Prosody) ( $p = 0.8$ ). The model, displayed  
323 in Table 3, shows that Ironic prosody leads to significantly higher irony scores  
324 than all other types of prosody. Since, however, other levels of Type do not  
325 seem equivalent (see Figure 3), we conducted post-hoc comparisons, which  
326 confirmed that Literal No type was rated as significantly less ironic than  
327 Literal Yes ( $z = -16.48$ ,  $p < 0.001$ ) and Neutral ( $z = -17.37$ ,  $p < 0.001$ ),  
328 while there was no difference between Literal Yes and Neutral types ( $p =$   
329  $0.92$ ).

330 *Facial expression (Video data)*. Figure 4 displays irony rating on a (1-7)  
331 Likert scale per type of facial expression. Cumulative link multilevel logit

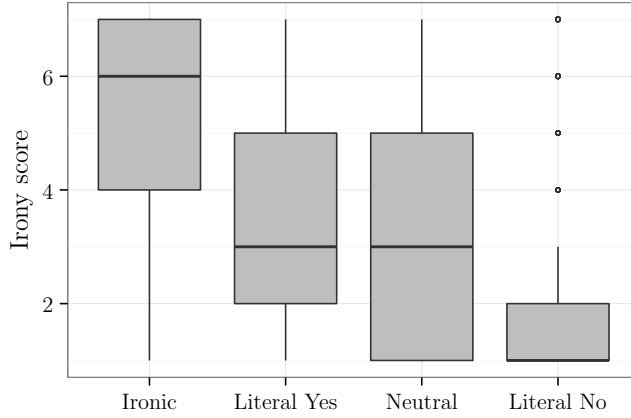


Figure 3: Tukey box-plots for ratings of audio-files per Prosody type

332 regressions with by-subject random intercepts and random slopes for the  
 333 Type factor (Ironic vs. Literal Yes vs. Neutral vs. Literal No) revealed a  
 334 significant effect of Type ( $\chi^2(3) = 176.58$ ,  $p < 0.001$ ), but not of Group  
 335 (Prosody-Facial Expression vs. Facial Expression-Prosody;  $p = 0.38$ ). As  
 336 shown in Table 4, Ironic facial expression prompts significantly higher irony  
 337 scores relative to other types of facial expression. Again, Figure 4 suggests  
 338 that not all non-ironic levels are equivalent; post-hoc comparisons show that  
 339 Literal Yes type is judged more ironic than Neutral ( $z = 7.9$ ,  $p < 0.001$ ) and  
 340 Literal No ( $z = 11.81$ ,  $p < 0.001$ ), and that Neutral type is judged more  
 341 ironic than Literal No ( $z = 5.17$ ,  $p < 0.001$ ).

### 342 Discussion

343 Experiment 1 confirms that in a rating task that explicitly opposes ironic  
 344 to literal stimuli, ironic prosody and facial expression can be correctly dis-  
 345 criminated against literal (positive or negative) or neutral prosody and facial

Irony ratings of prosody	
Literal Yes	-1.38 (0.09)***
Neutral	-1.62 (0.09)***
Literal No	-3.61 (0.15)***
1—2	-2.78 (0.08)***
2—3	-1.84 (0.07)***
3—4	-1.32 (0.07)***
4—5	-0.76 (0.07)***
5—6	-0.16 (0.06)*
6—7	0.68 (0.06)***
Num. obs.	5040

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$

Table 3: Coefficients (and standard errors) of fixed effects of the cumulative link multilevel logit regressions of irony ratings on Prosody Type on irony ratings (Ironic prosody is the reference level). The three first lines of the table report the coefficients for the predictors included in the CLMM. Lines 4 to 9 report the coefficients for each transition of the 7-point Likert scale.

346 expression. However, using a gradual Likert scale instead of a forced ‘ironic  
 347 vs. literal’ binary choice (unlike, e.g. [Bryant & Fox Tree, 2002](#); [Voyer et al.,](#)  
 348 [2016](#)) allows a finer-grained insight into the identification of prosody and  
 349 facial expression as ironic or not. Of course, ironic prosody and facial ex-  
 350 pression led to unambiguously higher scores on an irony scale. (In the case of  
 351 ironic prosody, such perceptual judgements thus reflect the acoustic salience  
 352 of the stimuli intensity.) Recall, however, that our non-ironic audio and video  
 353 stimuli fall into three different types: positive prosody/expression, negative  
 354 prosody/expression and neutral prosody/expression. If ironic cues were com-  
 355 pletely unambiguous, one should expect the remaining three types to receive  
 356 the same ironic scores. And yet, literal positive prosody contours and facial

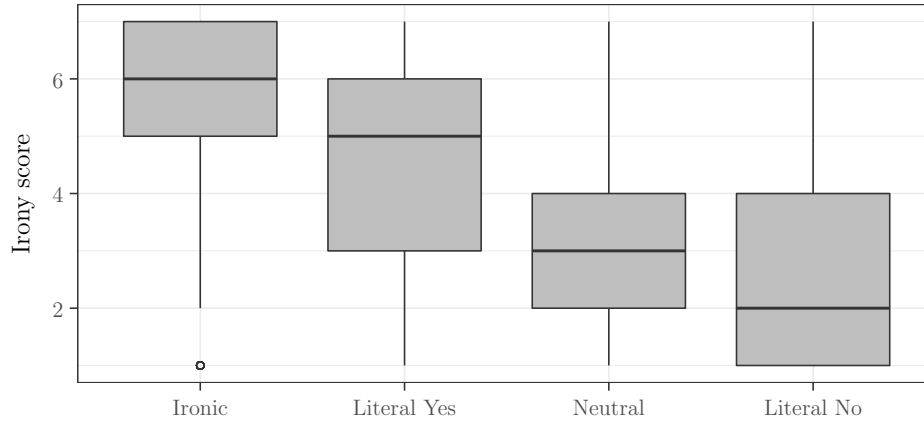


Figure 4: Tukey box-plots for ratings of video-files per facial expression type

expressions were judged more ironic than their literal negative counterparts. In other words, positive or neutral prosody and facial expression are more ambiguous as to the ironic vs. sincere meaning of an utterance. Furthermore, while ironic cues were accurately discriminated against the other ones as more ironic, the distinction could have been artificially boosted up by the fact that participants' task is reduced to merely rating the ironic dimension of various stimuli. In real life, however, interpreters have to decide on speaker's intentions rather than classify the utterance along an ironic-literal continuum. It is therefore likely that, in such settings, the actual reliability of non-contextual cues to irony is considerably lower than what the results of Experiment 1 might suggest.

## Experiment 2

The second experiment uses an act-out irony comprehension task in order to compare the impact of ironic prosody and facial expression relative to

Irony ratings of facial expressions	
Literal Yes	-1.42 (0.14)***
Neutral	-2.64 (0.15)***
Literal No	-3.28 (0.18)***
1—2	-4.21 (0.13)***
2—3	-3.10 (0.13)***
3—4	-2.42 (0.12)***
4—5	-1.58 (0.12)***
5—6	-0.71 (0.12)***
6—7	0.28 (0.12)*
Num. obs.	5292

\*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$

Table 4: Coefficients (and standard errors) of fixed effects of the cumulative link multilevel logit regressions of irony ratings on Facial expression Type (Ironic facial expression is the reference level). The three first lines of the table report the coefficients for the predictors included in the CLMM. Lines 4 to 9 report the coefficients for each transition of the 7-point Likert scale.

that of contextual incongruence. First, we expect that, in spite of being correctly discriminated in [Experiment 1](#) ironic prosody and facial expression, should not improve accuracy in irony comprehension relative to contextual incongruence. Second, in spite of not being associated with an accuracy gain relative to context, we expect these non-contextual cues to lead to shorter response times.

### Participants

Fifty-six students gave their written informed consent to participate in this study approved by the Faculty Ethics Committee at the Université libre de Bruxelles. Participants were recruited according to the following criteria: native French speakers, normal or corrected-to-normal vision, no hearing dif-

382 faculties, no history of neurological disorders. Ten participants were excluded  
383 from statistical analyses because they were not native speakers of French.  
384 Two other participants were excluded because they reported a history of  
385 attention-deficit/hyperactivity disorder, a neurodevelopmental disorder as-  
386 sociated with pragmatic deficits, including difficulties understanding irony  
387 (e.g. [Caillies et al., 2014](#); [Staikova et al., 2013](#); [Bignell & Cain, 2007](#)). The  
388 age of the 44 remaining participants (15 males) ranged between 18 and 26  
389 years ( $m = 20.43$ ;  $sd = 1.47$ ).

#### 390 *Procedure*

391 The task was run in 64-bit Windows 7 using Tobii Studio<sup>TM</sup> 3.2.1 soft-  
392 ware, which controlled the stimuli presentation in a random order and recorded  
393 participant’s response and reaction times. A Tobii pro X2-60(Hz) screen-  
394 based eye-tracker device (Tobii Technology, Inc. Stockholm, Sweden) was  
395 used to record participants’ eye movements during the target sentence. A  
396 five-point calibration procedure designed by Tobii Studio was used before the  
397 irony task.

398 Each participant was seated at a distance of  $\pm 60$  cm in front of a 16.5-inch  
399 monitor (resolution: 1920 x 1080 pixels) wearing headphones. The stimuli  
400 were presented at a comfortable sound pressure level (65dB  $\pm$  5dB). Follow-  
401 ing eye-tracker calibration, participants were presented with the following  
402 instructions on screen:

403 In each trial of this task you will watch videos with short conver-  
404 sations between two individuals. One person will ask a second  
405 person questions about two items on a table. After each ques-  
406 tion, you will watch a video with the second person’s reply. Listen

carefully to what the first person says and to the second person's  
reply! At the end of the second person's answer you will have  
to give him/her the item you believe he/she really wants. You  
should press the left mouse button if you think that he/she re-  
ally wants the item at the left or the right mouse button if you  
believe that he/she really wants the item at the right. Next trial  
will start automatically after your answer.

Participants first completed two training trials (one Literal Yes and one Lit-  
eral No item) before the experimental phase began.

## *Results*

In order to assess the relative impact of context, prosody and facial ex-  
pression, each stimulus was associated with a binomial variable Context,  
Prosody and Facial expression, depending on which cue(s) were associated  
with the target. Note that our Sincere No items were unambiguously literal.  
It is possible, then, that participants realize, in the course of the experiment,  
that any answer starting with 'No' would lead to a non-ironic interpretation.  
In order to assess this possibility, we examined the effect of the linear Order  
of the stimuli.

*Accuracy.* A correct interpretation of a target corresponds to a trial where  
the participant accurately selects the object the second character (B) in the  
video really wants (see [the description of the stimuli](#)). For Literal Yes items,  
the correct choice was the object named in the target (e.g. 'Yes, you know  
how much I like physics!'), whereas in Literal No (e.g. 'No, you know how  
much I hate physics!') and Ironic items (e.g. 'Yes, you know how much I



like physics!'), it was the other object displayed in the video. As can be seen from Figure 5, while accuracy rate is generally high, it is lower for Ironic targets.

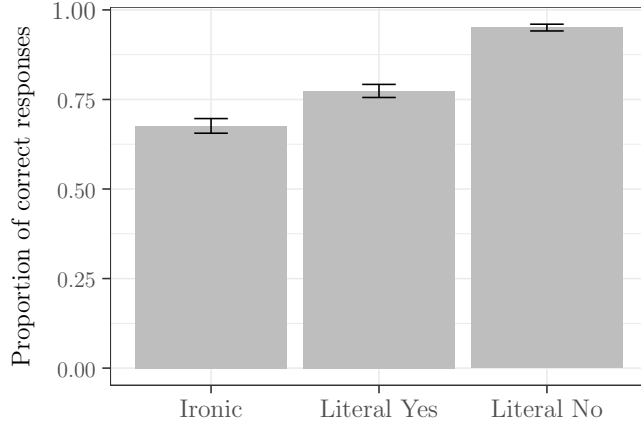


Figure 5: Proportions of correct responses by utterance Type (vertical bars represent standard errors)

Binomial logistic multilevel models, with the by-participant random intercepts were implemented using the `glmer` function of the `lme4` package (Bates et al., 2015). They revealed a significant effect of Type (Ironic vs. Literal Yes vs. Literal No;  $\chi^2(2) = 149.62$ ,  $p < 0.001$ ), as well as of Context ( $\chi^2(1) = 8.75$ ,  $p = 0.003$ ) and of Facial Expression ( $\chi^2(1) = 814.85$ ,  $p = 0.001$ ); there was no effect of Prosody ( $p = 0.14$ ) and of Order ( $p = 0.21$ ). Interactions between Type and Context ( $\chi^2(2) = 10.4$ ,  $p < 0.007$ ) and Type and Face ( $\chi^2(3) = 77.85$ ,  $p < 0.001$ ) were also significant. The model in Table 5 shows that Ironic targets elicit less correct responses than Literal No ones. The presence of Context strongly increases the accuracy on Ironic items. As for Facial expression, it has a detrimental effect on accuracy of

445 Ironic items; on the contrary, it increases the accuracy of Literal Yes relative  
446 to Ironic items.

	Accuracy
Intercept (Ironic)	0.45 (0.20)*
Literal No	2.68 (0.46)***
Literal Yes	0.05 (0.28)
Context	
Ironic X Context	0.86 (0.20)***
Literal No X Context	-0.33 (0.45)
Literal Yes X Context	0.07 (0.24)
Facial expression	
Ironic X Facial expression	-0.44 (0.20)*
Literal No X Facial expression	0.32 (0.41)
Literal Yes X Facial expression	1.98 (0.26)***
Num. obs.	1578

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$

Table 5: Coefficients (and standard errors) of fixed effects for the multilevel logistical regression of correct responses on target Type, Type X Context & Type X Facial expression

447 *Reaction times.* In each target, the speaker’s preference was entirely deter-  
448 mined once the word was uttered referring to the object s/he wanted or pre-  
449 tended to want (‘Yes, you know how much I like **physics!**’). Reaction times  
450 were recorded from the onset of the word referring to an object in the target  
451 until participant’s response. A negative reaction time means that participant  
452 responded before the onset of the target word. Boxplots in [Figure 6](#) suggest  
453 longer reaction times for Ironic targets. Linear multilevel regression models,  
454 with by-participant random intercepts and random slopes for the Type factor,  
455 were implemented with the `lmer` function of the `lme4` package ([Bates et al.,](#)  
456 [2015](#)). They revealed a significant effect of Type ( $\chi^2(2) = 31.36$ ,  $p < 0.001$ ),

457 Prosody ( $\chi^2(1) = 11.85$ ,  $p < 0.001$ ), and Facial Expression ( $\chi^2(1) = 5.3$ ,  
 458  $p = 0.021$ ), but not of Context ( $p = 0.48$ ). Interactions between Type and  
 459 Prosody ( $\chi^2(1) = 8.45$ ,  $p = 0.15$ ) and between Type and Facial expression  
 460 ( $\chi^2(2) = 21.166$ ,  $p < 0.001$ ) were also significant. Finally, there was also  
 461 an effect of Order ( $\chi^2(1) = 146.87$ ,  $p < 0.001$ ), but no interaction between  
 462 Order and Type ( $p = 0.61$ ). The model, displayed in [Table 6](#) reveals that  
 463 responding to Ironic targets takes longer than for the other two types and  
 464 that reaction times decrease along experimental trials. Both Prosody and  
 465 Facial Expression decrease reaction times for Ironic items. (Prosody also de-  
 466 creases the processing of Literal Yes, but increases that of Literal No relative  
 467 to Ironic items.)

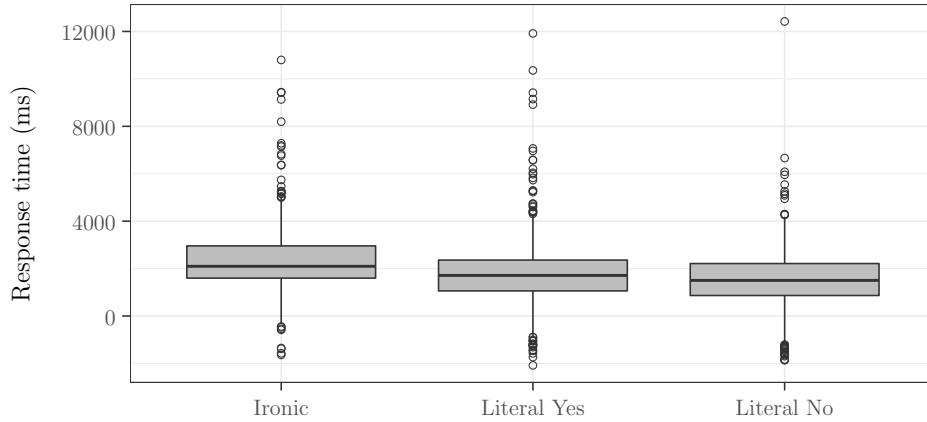


Figure 6: Tukey box-plots for reaction time per target type

468 *Eye-Tracking data.* We identified three areas of interest (AOI) for the target  
 469 sentence segment using Tobii Studio software (version 3.2.1): the speaker's  
 470 face (eyes plus lips regions), the correct and the incorrect objects (see [Figure](#)

	Reaction time
Intercept (Ironic)	3576.93 (220.77)***
Literal No	-1442.15 (174.05)***
Literal Yes	-754.39 (192.42)***
Order	-38.62 (3.07)***
Prosody	
Ironic X Prosody	-564.82 (121.77)***
Literal No X Prosody	216.16 (104.35)*
Literal Yes X Prosody	-321.43 (118.52)**
Facial expression	
Ironic X Facial expression	-457.33 (117.80)***
Literal No X Facial expression	-143.85 (98.26)
Literal Yes X Facial expression	14.45 (112.48)
Num. groups: Subject	44

\*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$

Table 6: Coefficients (and standard errors) of fixed effects of the multilevel linear regression of reaction time on target Type, Half , Type X Prosody & Type X Facial expression

7). The position of the AOI was manually adapted to the movements of the two actors in real time. Eye movement data for the target sentence segment was exported from Tobii using the I-VT fixation filter in the default setting. From the onset of the word referring to the object in the target, and for each AOI, we calculated the total fixation duration (i.e. the sum of the duration for all fixations within an AOI) and the fixation count (i.e. the number of times the participant fixates on an AOI). The fixation count and the total fixation duration were normalised according to participants' reaction times. For instance, number of fixations for the AOI 'correct object' = ([number of fixations on the correct object / time between the beginning of the target word until participant's response] \* 1000). We also coded whether participants' first three fixations went to the correct object, both from the

483 onset of the target utterance and from the onset of the word referring to the  
484 object in the target.



Figure 7: Areas of interest (AOIs) for the target sentence segment: the speaker's face (eyes plus lips regions), the correct and incorrect objects.

485 A linear mixed model on proportion of fixation durations with random  
486 by-participant intercepts revealed a significant effect of AOI ( $\chi^2(2) = 112.77$ ,  
487  $p < 0.001$ ), as well as a significant AOI X Type interaction ( $\chi^2(6) = 24.87$ ,  
488  $p < 0.001$ ). There was no interaction between AOI and Context, AOI and  
489 Prosody, and AOI and Facial expression (all  $ps > 0.14$ ). A linear mixed  
490 model on proportion of fixation counts with random by-participant intercepts  
491 also revealed a significant effect of AOI ( $\chi^2(2) = 69.12$ ,  $p < 0.001$ ) and a  
492 significant AOI and Type ( $\chi^2(6) = 23.76$ ,  $p < 0.001$ ). Additionally, there  
493 was a weak interaction between AOI and Context ( $\chi^2(3) = 8.69$ ,  $p = 0.034$ ),

494 but no interaction between AOI and Prosody ( $p = 0.88$ ), between AOI and  
 495 Facial expression ( $p = 0.086$ ), and between AOI, Type and Context ( $p = 0.4$ ).  
 496 As can be seen from the model summaries in Table 7, the most relevant result  
 497 – which is also fairly consistent with accuracy data – from fixation duration  
 498 and counts is that Literal No targets attracted longer and more numerous  
 499 fixations to the correct object than Irony ones.

	Proportions of fixation durations	Proportions of fixation counts
Intercept(Correct Object)	4.96 (2.64)	9.19 (3.04)**
Incorrect Object	-0.51 (2.63)	-3.34 (3.42)
Speaker's face	11.37 (2.28)***	8.94 (2.96)**
Type		
Correct Object X Literal Yes	2.70 (2.64)	2.94 (2.64)
Incorrect Object X Literal Yes	-1.23 (2.64)	-1.19 (2.64)
Speaker's face X Literal Yes	2.06 (1.87)	1.55 (1.87)
Correct Object X Literal No	11.76 (2.66)***	11.92 (2.66)***
Incorrect Object X Literal No	1.21 (2.66)	1.43 (2.66)
Speaker's face X Literal No	3.03 (1.88)	1.73 (1.88)
Correct Object X Context		-3.85 (2.30)
Incorrect Object X Context		-0.46 (2.30)
Speaker's face X Context		-3.93 (1.63)*
Num. obs.	5609	5608

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$

Table 7: Coefficients (and standard errors) of fixed effects of the multilevel linear regression of proportions of fixation durations and fixation counts on AOI, AOI X target Type, & AOI X Context

500 Turning to the first three fixations on the correct object from the be-  
 501 ginning of the target utterance, binomial multilevel models, with the by-  
 502 participant random intercepts revealed an effect of Type ( $\chi^2(2) = 35.56$ ,

503  $p < 0.001$ ), but no effect of Context, Prosody or Facial expression (all  
 504  $ps > 0.06$ ). There was also an effect of the Fixation Number (first, sec-  
 505 ond or third;  $\chi^2(1) = 32.93$ ,  $p < 0.001$ ), as well as interaction between Type  
 506 and Fixation Number ( $\chi^2(3) = 36.16$ ,  $p < 0.001$ ).

507 For the first three fixations on the correct object, computed from the  
 508 beginning of the word referring to the object, binomial multilevel models,  
 509 with the by-participant random intercepts also revealed an effect of Type  
 510 ( $\chi^2(2) = 19.17$ ,  $p < 0.001$ ) on the fixation on the correct object, but no  
 511 effect of Context, Prosody or Facial expression (all  $ps > 0.21$ ). Here too,  
 512 there was an effect of Fixation Number ( $\chi^2(1) = 123.02$ ,  $p < 0.001$ ), as well as  
 513 interaction between Type and Fixation Number ( $\chi^2(3) = 125.03$ ,  $p < 0.001$ ).  
 514 As can be seen from [Table 8](#), from the start of the target utterance, Literal  
 515 Yes – but not Literal No – items attract more anticipatory fixations to the  
 516 correct object than Ironic. Towards the end of the target utterance, however,  
 517 Literal No items – but not Literal Yes – are more likely to attract anticipatory  
 518 looks towards the correct object than Ironic items. For both measures (i.e.  
 519 target utterance and object mention), the probability to look at the correct  
 520 object increases from the first to the third fixation for all item types.

## 521 *Discussion*

522 Correct identification of the speaker’s goals is significantly lower for ironic  
 523 utterances; in that respect, our results parallel findings by [Kowatch et al.](#)  
 524 ([2013](#)), who used analogous utterance Types. Equally consistent with the  
 525 literature (e.g. [Kreuz & Roberts, 1995](#); [Gerrig & Goldvarg, 2000](#)) is our result  
 526 that incongruence with the preceding context increases the correct interpre-  
 527 tation of ironic utterances. Interestingly, ironic prosody does not facilitate

	First fixations (target utterance)	First fixations (object mention)
Intercept (Ironic)	-5.30 (0.54)***	-3.90 (0.32)***
Literal Yes	1.42 (0.59)*	0.39 (0.41)
Literal No	0.03 (0.67)	0.78 (0.38)*
Fixation number		
Ironic X Fixation number	0.58 (0.22)**	0.80 (0.13)***
Literal Yes X Fixation number	0.45 (0.14)***	0.72 (0.12)***
Literal No X Fixation number	0.76 (0.18)***	0.71 (0.11)***
Num. obs.	3905	3402
Num. groups: Subject	43	43

\*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$

Table 8: Fixed effects of the multilevel logistic regression of first fixations on the correct object (beginning from start the target utterance and from the start of the word referring to an object) target Type & Type X Fixation Number (first, second or third).

528 interpretation, and ironic facial expression actually hampers it, confirming  
529 that non-contextual cues for irony are not very reliable in a comprehension  
530 task.

531 We also found that ironic items elicit slower reaction times relative to  
532 the literal ones. Slower processing of ironic items, to a certain extent at  
533 least, is probably linked to the contextual assessment and rejection of the  
534 compositional, literal meanings (Giora, 2003). However, Experiment 2 also  
535 strongly suggests that context-based processing of irony may be aborted in  
536 the presence of a distinctive prosody and/or facial expression. A striking re-  
537 sult, which is consistent with our predictions, is that both ironic prosody and  
538 ironic facial cues dramatically decrease reaction times. Together, accuracy  
539 and reaction times results indicate that non-contextual cues entail a trade-off  
540 in irony interpretation. On the one hand, they are less reliable than context,



541 but, on the other hand, their presence prompts a faster processing. One  
542 explanation of this effect, in line with the model proposed by [Kissine \(2016\)](#),  
543 is that, in the presence of distinctive prosody and/or facial expression par-  
544 ticipants by-pass contextual interpretation of the literal meaning. Another,  
545 very similar interpretation is that both contextual and non-contextual cues  
546 are processed in parallel, but that the latter lead to faster decision, thus  
547 terminating the former. This finding is coherent with the parallel-constraint-  
548 satisfaction account ([Katz, 2005](#); [Pexman, 2008](#)), but allows to go a step  
549 further in evidencing the relative weight of the different cues in irony com-  
550 prehension. Note that, unlike us, [Kowatch et al. \(2013\)](#) found no difference  
551 in reaction times between ironic and literal items. Recall, however, that their  
552 stimuli were all associated with ironic prosody and no contextual cues. To  
553 the extent that prosody prompts faster (but less accurate) processing, this  
554 feature may explain the difference between their and our results.

555 Another clear-cut result of Experiment 2 is the advantage in processing  
556 for literal (‘No’) negative sentences. These items led to strikingly higher accu-  
557 racy rates and faster response times. Likewise, these items were associated  
558 with longer and more numerous fixations on the correct object, reflecting  
559 lesser hesitation as to the response. Further evidence for the advantage of  
560 Literal No items comes from first fixations. At the beginning of the target  
561 utterance, more looks go to the correct object in literal positive items, which  
562 is certainly due to the spill-over from the mention of the correct object in  
563 the preceding question (see [Figure 1](#) and [Table 1](#)). However, by the time  
564 the object is mentioned in the target, literal negative utterances trigger more  
565 anticipatory looks towards the correct object. One reason why Literal No

566 items stand apart could be that in our design all ironic items were associ-  
567 ated with positive ('Yes') sentences. However, neither accuracy nor reaction  
568 times for negative sentences change across the experiment, as revealed by  
569 the absence of the interaction between Type and Order. There is another  
570 reason why participants implicitly grasped the unambiguously literal nature  
571 of Literal No items. Irony is usually associated with negatively oriented read-  
572 ings of positive literal counterparts, whereas the opposite, ironic positive /  
573 literal negative valence is highly atypical (Kreuz & Link, 2002). One may  
574 surmise, then, that interpreters' language experience makes them sensitive to  
575 irony's negative valence. If so, our participants could rapidly associate nega-  
576 tive sentences with a non-ironic interpretation, without necessarily assessing  
577 the literal content relative to the context, or, for that matter, processing  
578 any other cue. In line with this idea, even though in Experiment 1 negative  
579 prosody was the most clearly distinguished from ironic, in Experiment 2 it  
580 tended to slow down reaction times. That is, information provided by literal  
581 negative prosody is made redundant by the negative valence of the sentence.

582     Returning to our main research questions, Experiment 2 strongly suggests  
583 that, as hypothesised in the Introduction, ironic prosody and facial expression  
584 are less reliable cues for irony comprehension than contextual incongruence,  
585 but that they entail an accuracy-processing speed trade-off. However, three  
586 methodological choices we made could be taken to somehow mitigate these  
587 results. First, recall that we decided not to include a condition with Facial  
588 expression, but no Prosody and Context. While the results of Experiment 2  
589 indicate that ironic Facial expression is not a fully reliable cue for the inter-  
590 pretation of ironic utterances, this cue was always associated with at least

591 another one. Second, our decision not to include Ironic No items (viz. ironic  
592 compliments), albeit fully justified from a methodological point of view (see  
593 above), entails an unbalanced experimental design, with more positive (Ironic  
594 and Literal Yes) than negative (Literal No) items. Third, we compared the  
595 reliability of a prosodic or contextual cue delivered alone or in combination  
596 with one or two other cues, but at no time these conditions were compared  
597 to a complete absence of cues. Adding a control condition without any cues  
598 would allow to appreciate more closely the reliability of isolated cues. Even  
599 though none of these three features is likely to impact the differential pro-  
600 cessing roles of contextual and non-contextual cues uncovered in Experiment  
601 2, we seek to determine, in Experiment 3, whether these effects are robust  
602 enough to show up in a fully balanced design.

### 603 **Experiment 3**

604 In Experiment 3 we seek to replicate the effects uncovered in Experiment  
605 2 using a perfectly balanced, between-subject design, while keeping exactly  
606 the same target sentences segments as in Experiments 1 and 2. In order to  
607 rule out any potential bias due to the presence of literal negative items, we  
608 kept only the Literal Yes and Ironic items of Experiment 2.<sup>5</sup> Using these

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<sup>5</sup> In theory, we could have balanced our design by adding negative ironic items. To begin with, such a design would have considerably increased the task duration, and hence the risk of biases due to cognitive fatigue. More importantly, and as already discussed above, negative ironic items are highly atypical (Kreuz & Link, 2002), and poorly comprehended even in discrimination tasks, which arguably are easier than our act-out paradigm (Climie & Pexman, 2008; Filippova & Astington, 2010). Interpretation of this less common type

609 items, we created two sets of stimuli – Context vs. No Context – presented  
610 to two different groups of participants. Stimuli presented to the Context  
611 Group included all possible combinations of Context with non-contextual  
612 cues: Context; Context and Facial expression; Context and Prosody; and  
613 Context, Prosody and Facial expression. Stimuli presented to the No Con-  
614 text Group pooled all combinations of non-contextual cues in the absence of  
615 Context: No cue; Prosody; Facial expression; Prosody and Facial expression.  
616 In this way, Experiment 3 provides a balanced design suited to isolate the im-  
617 pact of all three cues, and includes a condition with only a facial-expression  
618 cue and a control condition without any cues.

619 This between-subject design also allows to further test our Hypothesis  
620 2. In line with Experiment 2, we expect an overall effect of Group (Context  
621 vs. No Context) on accuracy: in the absence of contextual cues, partici-  
622 pants should be more error prone in gauging the speaker’s ironic intent. If,  
623 as we hypothesise, processing of non-contextual cues is privileged at the ex-  
624 pense of context-based assessment of the utterance content, the presence of  
625 ironic prosody and/or facial expression should lead to comparable accuracy in  
626 both Context and No Context groups. Furthermore, we also predict contex-  
627 tual processing not to be completed in the presence of these non-contextual  
628 cues. Accordingly, the presence of the non-contextual cues lead to shorter  
629 response times in both groups, which would indicate, in the Context group,  
630 that contextual processing has been aborted. If, by contrast, non-contextual  
631 cues supplement full processing of contextual cues, one should expect ironic

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of irony is thus a topic orthogonal to the relative roles of contextual and non-contextual cues, and clearly falls out of the scope of this paper.

632 prosody and facial expression to increase accuracy in the Context group, and  
633 to lead to longer response times.

#### 634 *Participants*

635 Forty-seven undergraduate students, none of whom took part in Experi-  
636 ments 1 and 2, participated for monetary reward in Experiment 3. Inclusion  
637 criteria were similar to Experiment 2. One participant was excluded from sta-  
638 tistical analyses for technical reasons. The Context group (N=23) consisted  
639 of 13 women and 10 men between 19 and 29 years ( $m = 22.70$ ;  $sd = 2.60$ ),  
640 and the No Context group consisted of 15 women and 8 men between 20 and  
641 28 years ( $m = 22.83$ ;  $sd = 2.50$ ).

#### 642 *Procedure*

643 Two groups of sixteen videos from the previous set of videos were used  
644 to form the Context and No Context group. Target sentences in the Context  
645 group were always associated with a Contextual cue and were subdivided  
646 in 4 categories depending on the presence (+) or the absence (-) of prosody  
647 and/or facial expression cues: Context only (C+P-F-), Context & Prosody  
648 (C+P+F-), Context & Facial expression (C+P-F+), Context, Prosody &  
649 Facial expression (C+P+F+) conditions. In the No Context group, the tar-  
650 get sentence was never associated with a Contextual cue; stimuli were also  
651 subdivided in 4 categories depending on the presence (+) or absence (-) of  
652 prosody and facial expression cues: No cues (C-P-F-), Prosody only (C-P+F-  
653 ), Facial expression only (C-P-F+), Prosody & Facial expression (C-P+F+)  
654 conditions. Each category is composed of 2 Ironic and 2 Literal Yes items  
655 (see [Table 9](#)).

Group	Context			No Context		
	Context	Prosody	Facial expression	Context	Prosody	Facial expression
	+	-	-	-	-	-
	+	+	-	-	+	-
	+	-	+	-	-	+
	+	+	+	-	+	+

Table 9: Design of Experiment 3

656 To obtain the items in the No cues (C-P-F-) and in the Facial expres-  
657 sion only (C-P-F+) conditions, we used the same videos as in the Context  
658 only and Context & Facial expression conditions from the Context group,  
659 removing the context segment from the videos.

## 660 *Results*

661 In order to uncover the roles of ironic prosody and facial expression, as  
662 in [Experiment 2](#), we associated each item with binomial Prosody and Facial  
663 Expression factor, depending on which cue(s) were associated with the target.

664 *Accuracy.* [Figure 8](#) displays the proportions of correct responses by Group,  
665 Type and non-contextual cue. Accuracy was analyzed building hierarchical  
666 binomial logistic multilevel models, with the by-participant random inter-  
667 cepts, using the `glmer` function of the `lme4` package ([Bates et al., 2015](#)). As  
668 predicted, there was a significant effect of Group (Context vs. No Con-  
669 text;  $\chi^2(1) = 7.94$ ,  $p < 0.005$ ). There was also an effect of Type (Literal  
670 vs. Ironic;  $\chi^2(1) = 5.78$ ,  $p < 0.001$ ), but no Group X Type interaction  
671 ( $p = 0.42$ ). There was no effect of Prosody ( $p = 0.17$ ), but an effect of

672 Facial expression ( $\chi^2(1) = 36.2, p < 0.001$ ). The Type X Facial expression  
673 interaction was significant ( $\chi^2(1) = 8.32, p < 0.004$ ), but not the Group X  
674 Facial expression ( $p = 0.49$ ). That is, ironic prosody and facial expression  
675 have a comparable effect in both groups, indicating that their presence does  
676 not have a cumulative effect on accuracy in the Context group.

677 In order to assess further our predictions, we conducted post-hoc com-  
678 parisons of least square-means on the final model. As predicted, overall  
679 accuracy is significantly lower in the No Context group ( $\beta = -0.53, se =$   
680  $0.18, p = 0.0036$ ). Overall accuracy was higher on Ironic than on Literal  
681 items ( $\beta = 0.6, se = 17, p = 0.0005$ ). In other terms, in this irony compre-  
682 hension task, the rate of false alarms exceeds misses.<sup>6</sup>

683 *Reaction times.* As in Experiment 2, reaction times were recorded from the  
684 onset of the word referring to an object in the target until participant's  
685 response. Response times, per Group, Type and non-contextual cue are  
686 summarised in [Figure 9](#). Linear multilevel regressions, with by-participant  
687 random intercepts revealed no effect of Group or of Type ( $ps > 0.7$ ). However,  
688 there was an effect of Prosody ( $\chi^2(1) = 5.38, p < 0.02$ ) and Facial expression  
689 ( $\chi^2(1) = 5.58, p = 0.018$ ). As predicted, reaction times were shorter in the  
690 presence of Prosody ( $\beta = -335.1, se = 144, p < 0.02$ ) and Facial expression  
691 ( $\beta = -344, se = 145.4, p = 0.018$ ), across Groups and Type.<sup>7</sup>

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<sup>6</sup>The Type X Facial expression interaction it was due to the fact that literal marked  
Facial expression improved accuracy on Literal items (viz. reduces the rate of false alarms;  
 $\beta = 1.46, se = 0.24, p < 0.0001$ ).

<sup>7</sup>Using the same method as in Experiment 2 and the same AOIs (see [Figure 7](#)), we  
also analysed total fixation durations and fixation counts. Hierarchical multilevel linear

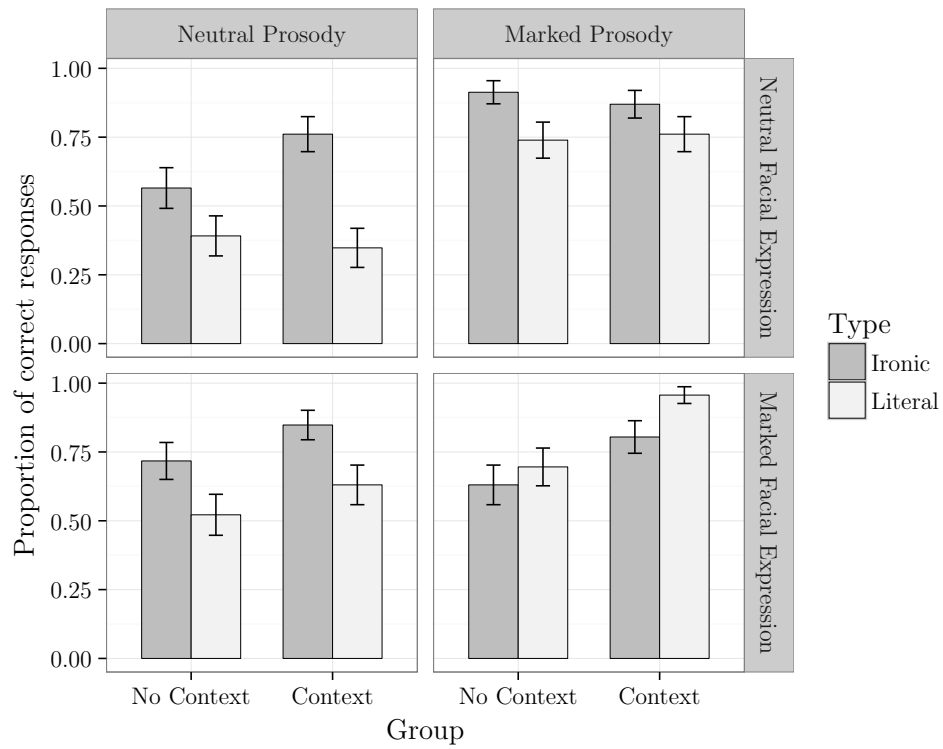


Figure 8: Proportions of correct responses per group, target type and non-contextual cue (vertical bars represent standard errors)



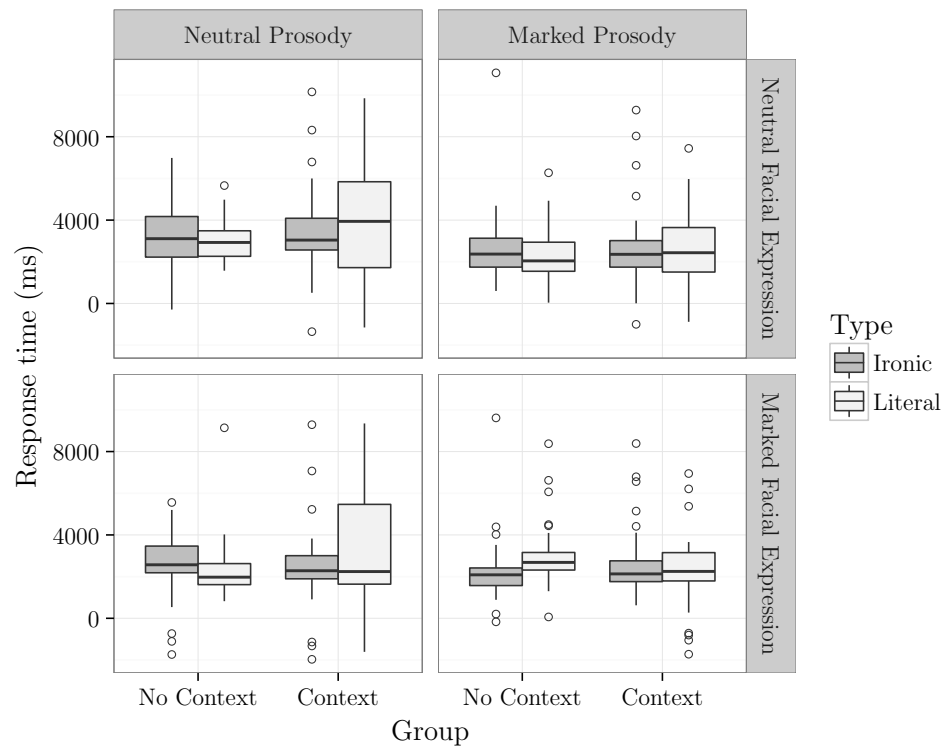


Figure 9: Tukey box-plots for reaction time per group, target type and non-contextual cue

692 *Discussion*

693 Results of our Experiment 3 are entirely consistent with those of [Experiment 2](#), and provide supplementary confirmation for our hypotheses. To  
694 begin with, we confirm that contextual incongruence is a much more reliable  
695 cue for irony than ironic intonation and facial expression. That is, in line with  
696 [Experiment 2](#), high discriminability of these cues, evidenced in [Experiment](#)  
697 [1](#), does not translate into comparable reliability in an act-out comprehension  
698 task.

700 Furthermore, in Experiment 3 ironic prosody and/or facial expression do  
701 not have a cumulative effect with contextual incongruence; if they did, their  
702 presence should have entailed higher accuracy in the context group. This  
703 result suggests that, as predicted by our [Hypothesis 2](#), intonation and/or fa-  
704 cial expression are salient cues that prompt interpreters to terminate costlier  
705 context-based processing. This interpretation is reinforced by the fact that,  
706 as in [Experiment 2](#), ironic prosody and facial expression are associated with  
707 a processing speed-accuracy trade-off. That is, in spite of being less re-  
708 liable than contextual incongruence for irony comprehension, the presence  
709 of prosody and/or facial expression is associated, in both Context and No  
710 Context groups, with shorter response times.

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regressions with by-participant random intercept revealed an effect of AOI on total fixation durations ( $\chi^2(2) = 113.58, p < 0.001$ ). However, there is no interaction with Group, Type, Prosody and Facial expression (all  $ps > 0.38$ ). As for fixation counts, there was no effect of AOI ( $p = 0.16$ ). These data are orthogonal to the main point of Experiment 3 and will not be discussed further on.

## 711 General discussion

712 While ironic prosody and facial cues can be accurately categorized in a  
713 discrimination task ([Experiment 1](#)), they do not lead to better grasp of irony  
714 in a task where participants must make a decision about the speaker’s com-  
715 municative goals ([Experiments 2 and 3](#)). An obvious upshot of our paper,  
716 then, is methodological. Researchers should be wary of drawing conclusions  
717 about figurative language comprehension based on forced-choice categoriza-  
718 tion tasks. The asymmetry between discrimination and use is probably due  
719 to the fact that perceptual thresholds between ironic vs. non-ironic prosody  
720 and facial expression are not entirely clear-cut. This was made clear by the  
721 irony ratings in [Experiment 1](#), which showed that literal positive and neu-  
722 tral cues are perceived as more ironic than their negative counterparts. The  
723 relative fuzziness of these boundaries has probably less importance in a task  
724 where participants have to focus exclusively on locating audio or video stim-  
725 uli on an irony scale, but they can lead to more incorrect responses when  
726 participants have to make decisions on speaker’s goals. In other terms, cat-  
727 egorization of ironic prosody and facial cues can be carried out off-line, but  
728 is much more difficult on-line.

729 A potential limitation here could be our use of professional actors in the  
730 video stimuli. Although it is a standard practice in the literature on irony  
731 (e.g. [Rockwell, 2000](#); [Anolli et al., 2000](#); [Attardo et al., 2003](#); [Rankin et al.,](#)  
732 [2009](#)), there is a risk that prosody and facial expression may have been over-  
733 played. Recall, however, that results of [Experiment 1](#) did not show any ceiling  
734 effect in rating score of prosody and facial expression, and that they led to  
735 far from perfect detection of irony in [Experiments 2 and 3](#). To the best of

our knowledge, no study compares prosody and facial expression associated with ironic statements in actors, untrained confederates or in spontaneous speech. One study of acoustic correlates of spontaneous verbal irony reports slower delivery rate as the only robust prosodic characteristic of ironic utterances (Bryant, 2010). A slowdown in speech rate has also been reported in studies using actors (Rockwell, 2000; Anolli et al., 2000), as well as in the current paper. It would be interesting to replicate our findings using recordings of verbal irony in real life situations. However, studying the interplay between ironic cues requires to tightly control the structure of the context segment and the target sentence, which is extremely difficult to achieve in real situations.

The trade-off between accuracy and reaction times, which emerged from Experiments 2 and 3, might look very much like a conceptual conundrum. On the one hand, it seems clear that neither ironic prosody nor ironic facial expression form natural kinds (in line with Bryant & Fox Tree, 2005); on the other hand, participants do seem to privilege such cues, at the expense of accuracy, whenever these are available. On second thought, however, the contradiction is only apparent. Any definition of irony, be it framed in terms of echo or pretence, includes the incompatibility between the context and a literal interpretation of the utterance (Kumon-Nakamura et al., 1995; Wilson, 2006). This is why the capacity to distinguish lies from jokes is operational only if one can make context-based hypotheses about what the speaker wanted the hearer to believe (Wimmer & Leekam, 1991; Martin & McDonald, 2004). It is also for this reason that, as shown by Experiments 2 and 3, assessing the utterance content relative to the background context

761 remains the most reliable route to grasp ironic meanings. In that sense,  
762 contextual assessment of the literal meaning is, indeed, an essential part of  
763 irony processing, as predicted, for instance, by [Giora \(2003\)](#) and [Sperber &  
764 Wilson \(2002\)](#). Yet, even though our results vindicate the central role of  
765 context in irony comprehension, they also indicate, consistently with the sec-  
766 ond prediction made in the [Introduction](#), that irony processing is not always  
767 context-based. One may speculate that along with our communicative expe-  
768 rience, grows implicit knowledge that ironic utterances are often accompanied  
769 by distinctive prosody or facial expression. Mature communicators may then  
770 privilege (what they perceive as) ironic prosody and/or facial expression to  
771 speed up the comprehension process. That is, unreliable as they are, these  
772 non-contextual cues lead to an activation of ironic meanings without the  
773 full-fledged, compositional interpretation being completed.

774 Such a processing route is fully compatible with the Direct Access model  
775 ([Gibbs, 2002](#)). It can also be implemented within the parallel-constraint-  
776 satisfaction model ([Katz, 2005](#); [Pexman, 2008](#)), provided that this model is  
777 amended in way to allow salient non-contextual cues to terminate context-  
778 based processing before it is complete. In a way, then, our findings lay ground  
779 for reconciling these two models with more context-based theories of irony.  
780 It is generally plausible that frugal heuristics are privileged by interpreters  
781 whenever possible (in line with, for instance, [Ferreira & Patson 2007](#); [Shintel  
782 & Keysar 2009](#); [Epley et al. 2004](#); [Kissine 2016](#)). Assessing the utterance  
783 content to the context is a relatively complex, and arguably costly process,  
784 so it is not entirely surprising that interpreters forgo it in the presence of  
785 more salient cues (as also evidenced by [Deliens et al., 2017](#)).

786 Participants' failure to see that prosody and facial expression are not as  
787 reliable as context-based assessment can be profitably conceived of as an in-  
788 stance of meta-cognitive error (in the sense of, e.g., [Koriat, 2000](#); [Proust,](#)  
789 [2013](#)). According to [Kissine \(2016\)](#), context – understood, this time, as the  
790 entire interactional frame of the utterance, including intonation and/or fa-  
791 cial expression – plays a two-pronged role in pragmatic processing. On the  
792 one hand, it determines the interpretative goal, including, for instance, the  
793 level of the specificity of the interpretation output. On the other hand, it  
794 is used to monitor and control the interpretation process that has been de-  
795 termined by this goal. For instance, the interpretative goal in [Experiment 1](#)  
796 consists in mere discrimination of an ironic or not character of a stimulus,  
797 which is less complex than genuinely accessing the speaker's intention, as  
798 in [Experiments 2](#) and [3](#). Such a superficial ironic interpretation may thus  
799 be reached without attempting to assess the speaker's intentions. However,  
800 non-contextual processes are less reliable to achieve the more complex in-  
801 terpretation goals mandated by the tasks in [Experiments 2](#) and [3](#). Relying  
802 on ironic prosody and/or facial expression in these cases, at the expense of  
803 context-based processing, thus reflects a meta-cognitive bias, driven by cog-  
804 nitive economy principles, which leads participants to select an interpretation  
805 process less than optimally suited for the interpretative goal at hand.

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