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Prosody and gesture in the interpretation of *yes*-answers to negative *yes/no*-questions

Abstract: In this paper we investigate the role of prosody and gesture in the interpretation of *yes*-answers to negative *yes/no*-questions in Catalan, a language with a polarity-based system of confirmation/contradiction of negative *yes/no*-questions. Two rating experiments were conducted to test (i) whether *yes*-answers to negative *yes/no*-questions are perceived as ambiguous by Catalan speakers when prosody and gesture are not available (Experiment 1), and (ii) whether the interpretation of *sí* 'yes' as an answer to a negative *yes/no*-question is dependent on prosodic and gestural properties of the answer (Experiment 2). Our results show that *yes* always asserts a salient propositional discourse referent, which can be either *p* or *¬p*. Intonation and gesture guide the interpretation of *yes*-answers to negative *yes/no*-questions in Catalan, and we show that a *yes*-answer with a marked intonation and gesture is to be interpreted as a denial or REJECT of a salient propositional discourse referent.

Keywords: *yes*-answers, negative *yes/no*-questions, ambiguity, prosody, gesture

1 Introduction

It has been discussed in the linguistics literature that languages diverge with respect to how their speakers confirm and contradict negative questions. In broad terms, languages can display either a *truth-based system* or a *polarity-based system* (Kuno 1973; Morris-Jones 1999; Levinson 2010; Holmberg 2013). In the former kind of answering system, which is used in languages such as Cantonese and Japanese (among others), negative questions are confirmed by answering *yes* and contradicted by answering *no*. This is illustrated in (1) and (2) for Cantonese.

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(1) Q: *keoi-dei   m   jam   gaafe?*
       he/she-PL   not   drink   coffee
       'Don't they drink coffee?'
    A: *hai.*
       yes ['They don't drink coffee']
    (Holmberg 2013: 33, example (6))

(2) Q: *keoi-dei   m   jam   gaafe?*
       he/she-PL   not   drink   coffee
       'Don't they drink coffee?'
    A: *m   hai.*
       not   yes/is ['Yes, they do']
    (Holmberg 2013: 33, example (9))

The truth-based system has also been referred to as the *agreement/disagreement system* (Holmberg 2013: 32), which captures the fact that the speaker agrees to the negative proposition in the negative question when confirming with a *yes*-answer, and disagrees to it when contradicting with a *no*-answer.

The relationship between *yes/no*-answers to negative *yes/no*-questions and the confirming/contradicting function is not so straightforward in languages with a polarity-based system. In English, for example, while a *no*-answer unambiguously confirms the negative proposition conveyed by the negative question (i.e., 'John is not coming'), as in (3), a *yes*-answer can be ambiguous between a contradiction and a confirmation reading, as in (4) (Ladd 1981; Romero and Han 2004; Holmberg 2013).

(3) Q: *Isn't John coming?*
    A: *No.* ['John is not coming']

(4) Q: *Isn't John coming?*
    A: *Yes.* [Interpretations. Contradiction reading: 'John is coming', and confirmation reading: 'John is not coming']

While *yes*-answers to negative *yes/no*-questions seem to be ambiguous in English when negation is affixed to the verb, it appears that this is not so for negative *yes/no*-questions with non-contracted negation.[1]

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1 In (i), for instance, the *yes*-answer is most often interpreted as having a confirmation reading, as happens with the *no*-answer as well.

(i) Q: *Is John not coming?*
    A: a. *Yes.* ['John is not coming']
       b. *No.* ['John is not coming']

In Catalan, the language on which we focus in this paper, the situation seems to be similar to the one illustrated in (4) for English. Pilot results based on written materials (i.e., with no access to prosodic and gestural information) collected by the authors (see below Experiment 1) revealed that a *yes*-answer to a negative *yes/no*-question appears to be ambiguous between a contradiction and a confirmation reading.

(5) Q: *(Que)   no   ha   arribat,   ta mare?*[2]
      that   not   has   arrived   your mother
      'Hasn't your mother arrived?'
  A: *Sí.*
      yes
      [Interpretations. Contradiction reading: 'Yes, my mother has arrived', and confirmation reading: 'No, my mother hasn't arrived']

On a first approximation to the data in (5) it seems that, in negative questions about *p*, a *yes*-answer is interpreted with a contradiction reading (i.e., 'My mother has arrived'), as *yes* contradicts the commitment state of the speaker of the question that the addressee's mother has not arrived. By contrast, in a question about ¬*p*, *yes* has a confirmation reading (i.e., 'My mother hasn't arrived'), since *yes* confirms the commitment state of the speaker of the question that the addressee's mother has not arrived.

Interestingly, in French, *oui* 'yes' cannot be used to reject the negative salient propositional discourse referent in the negative question. The word *si* 'yes' needs to be used instead (Morris-Jones 1999; Holmberg 2013), as shown in (6).

Holmberg (2013) reports that there seems to be a fair amount of variation among speakers with respect to how acceptable a *yes*-answer to a question like (i) is. Some speakers find an answer like (ia) non-felicitous with a confirmation reading and prefer a *yes*-answer followed by a clause with ellipsis (*Yes, he did*) to convey a contradiction reading.

    It has also been pointed out that it is possible to favour a confirmation reading of *yes* when the negative marker in the question is stressed. Stress is marked by the capitals in (ii). Stress indicates that negation is low, with its scope restricted to the vP.

(ii) Q: *Is John NOT coming?*
   A: *Yes.* [Preferred reading for several speakers: 'John is not coming']
   (Holmberg 2013: example (11))

2 In Catalan, *yes/no*-questions can be optionally headed by an overt question marker *que* 'that' (Prieto and Rigau 2007). These authors claim that the pragmatic value of *que* together with intonation is related to a modality difference, in the sense of expressing a positive speaker's presupposition.

(6) Q: *Il   n'   aime   pas   du café?*
      he   NEG   like-3SG   NEG   coffee
      'Doesn't he drink coffee?'
   A: a. **Oui.*
         yes
      b. *Si.*
         yes ['Yes, he does']
      (Holmberg 2013: 33, example (8))

To summarise, it seems that in languages with a polarity-based system like English and Catalan, *no*-answers confirm the negative proposition expressed by a negative question, while *yes*-answers seem to be ambiguous. One possible way to approach this 'ambiguity problem' is to suppose that there is more than one possible structural position where negation can be interpreted. Yet, little is known about the role intonation and gesture can play in the interpretation of *yes*-answers to negative *yes/no*-questions.

The purpose of the present paper is to experimentally test (i) whether *yes*-answers to negative *yes/no*-questions in Catalan are perceived as ambiguous by native speakers when prosody and gesture are not available; (ii) whether this apparent ambiguity can be attributed to the fact that the negation in the question occurs and is interpreted in different structural positions in the syntactic representation, or, rather, to the fact that it is the output of different speech acts: asserting a negative proposition or rejecting an assertion; and (iii) whether the interpretation of *sí* 'yes' as an answer to a negative *yes/no*-question is dependent on prosodic and gestural properties of the answer. If intonation and gesture turn out to be relevant for the interpretation of *yes*-answers to negative *yes/no*-questions in Catalan, interesting questions emerge with respect to the design of grammar and the directionality of the interaction between the interfaces.

The paper is organised as follows. In Section 2, we briefly present the theoretical debate that is at the starting point of our experimental study. In Section 3, we present the methods and results for Experiment 1. Section 4 presents methods and results for Experiment 2. Finally, in Section 5 we discuss our findings and summarise the most relevant conclusions of the study.

2 Theoretical debate

The English and the Catalan data presented in the Introduction raise a fundamental question: what is the origin of the double interpretation attributable to

yes-answers? Is it the *yes*-answer, the negative question, or none of them that are ambiguous?

Since Ladd (1981) the assumption has been that negative questions are a challenge for semantics and pragmatics because they are systematically ambiguous, depending on whether the speaker of such a question is asking for confirmation of *p* or ¬*p*.

According to Holmberg (2013), the negation in the question can be interpreted in different structural positions in English, giving rise to different interpretations and degrees of acceptability of bare *yes*-answers. He distinguishes between highest, middle and low negation in English to account for the differences in the interpretation and acceptability of bare *yes*-answers to negative *yes/no*-questions.[3]

Romero and Han (2004) and Romero (2006) focus on the scope difference of the negation in the question, and on the potential scope ambiguity of negation with respect to an abstract VERUM operator (i.e., an epistemic operator that relates to the strength with which a proposition should be added to the common ground).

There is a slight correlation between Holmberg's highest syntactic negation and Romero and Han's (2004) semantic ¬*VERUM(p)*, whereas middle negation appears to correspond to *VERUM(¬p)*.

Besides these works, Repp (2013) postulates that, in addition to Romero and Han's *VERUM* operator, there is a *FALSUM* operator, which states that the degree of strength with which the proposition should be added to the common ground is zero; that is, *FALSUM* is the same operator that occurs in denials. High negation is interpreted as *FALSUM*, and sentential negation as ¬*p*. However, as pointed out

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3 Holmberg (2013: 48) makes a distinction between highest negation (interpreted outside IP), middle negation (interpreted inside IP, but with sentential scope) and low negation (vP-scope).

(i)   Highest negation (interpreted outside IP)
      Q: Isn't John coming (too)? (positive bias)
      A: Yes. ('John is coming.') / A: No. ('John is not coming.')

(ii) Middle negation (interpreted inside IP, but with sentential scope)
      Q: a. Isn't John coming (either)? (negative bias; unacceptable for some speakers)
         b. Is John not coming?
      A: #Yes. (indeterminate/uninterpretable in this context) / A: No. ('John is not coming.')

(iii) Low negation (vP-scope)
      Q: Is John not coming?
      A: Yes. ('John is not coming.') / A: No. ('John is not coming.')

Whereas in highest and low negation bare *yes*-answers are felicitous and straightforwardly interpreted as either contradicting (highest) or confirming (low) the negative proposition in the question, bare *yes*-answers to *yes/no*-questions with middle negation are not acceptable and are difficult to interpret by the speakers.

by Krifka (to appear) the real theoretical puzzle is why negation can either express propositional negation on the one hand, and the *FALSUM* operator on the other.

As for English, it has been postulated that a test that proves the existence of highest and middle positions for negation in the clausal structure of questions consists in combining the clause with polarity items such as *too* or *either* (Romero and Han 2004).[4] In Catalan, highest and middle negation can also be distinguished using a similar test: the positive and negative polarity items *també* 'too' and *tampoc* 'either' indicate whether the negative marker *no* is to be interpreted outside or inside the IP. Consider the data in (7) and (8).

(7) Q: *(Que) no   has   publicat   a   LI, també?*
       that   not   have.2SG   published   in   LI too
      'Isn't it true that you have published in LI, too?'
  A: *Sí.*
     yes
     'Yes'

(8) Q: *(Que) no   ha   arribat,   ta mare,   tampoc?*
       that   not   has   arrived   your mother   either
      'Hasn't your mother arrived, either?'
  A: *#Sí.*
     yes

The interpretation of the answer in (7) and (8) depends on the fact that the elliptical answer may have either the IP or the NegP of the question as antecedent *p*'s. However, whereas in (7) the adverb *també* indicates that the salient propositional discourse referent is IP, in (8) the adverb *tampoc* indicates that the salient propositional discourse referent is NegP. This distinction correlates with the fact that the interpretation of the *yes*-answer in (7) is a confirmation of 'having published in LI', while the interpretation of the *yes*-answer in (8) is pragmatically

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4 Outer or highest negation in combination with *too* is exemplified in (i), whereas inner or middle negation in combination with *either* is exemplified in (ii).

(i) Q: *Isn't John coming, too?*
   A: *Yes.* ['John is coming']
   (Holmberg 2013: 31, example (2))

(ii) Q: *Isn't John coming, either?*
   A: a. *#Yes.*
      b. Yes, he is.
   (Holmberg 2013: 31, example (31))

awkward. This ill-formedness is somehow expected, because (8Q) being a question about ¬*p*, the expected answer is *no* (Wilson and Sperber 1988), rather than *yes*.

With these antecedents in mind, our proposal for (7) and (8) is that the negative marker in the question is the syntactic head of Neg⁰, just above IP (or Tense Phrase). This means that, from a syntactic perspective, the negative marker of *yes/no*-questions is not syntactically ambiguous, as it may only occur as the head of NegP. However, from a semantic perspective a negative *yes/no*-question can be a QUESTION about ¬*p* (e.g., 'Hasn't your mother arrived?') or a REQUEST on a second-level assertion that includes the implicatures or commitment states that the speaker of the question adds to the common ground, shared by speaker and addressee (e.g., the speaker's request on his/her belief that the addressee has published in LI). This view supports the idea that the supposed ambiguity of the question is not syntactic, but is rather at the level of interpretation of speech acts (cf. Krifka to appear).

Holding these assumptions, what we need to account for is: (i) why (8A) is considered inappropriate; (ii) whether this is due to a low degree of certainty of the speaker of the answer with respect to ¬*p*, or to a low degree of naturalness of a *yes*-answer to an expected *no*-answer, or to both; and (iii) whether with a marked intonation and gesture the reply in (8A) improves in acceptability and interpretability, as a denial or REJECT of the salient propositional discourse referent.

In order to provide an answer to these questions, we ran a first experiment in which we focused on the interpretation of written sentences. In a second experiment we focused on the interpretation of oral sentences. Before running this second experiment, production data were obtained with a Discourse Completion Task[5] (henceforth DCT, Blum-Kulka, House and Kasper 1989; Billmyer and Varghese 2000; Félix-Brasdefer 2010) conducted with three Catalan speakers (see section 4.1.3 Materials for Experiment 2). This DCT showed that intonation and gesture may be playing an important role in the interpretation of *yes*-answers to questions like (5), something which should not come as a surprise, as it has been demonstrated that gesture facilitates the interpretation of linguistically relevant material (Jouitteau 2004 for French null subjects; Malisz and Karpiński 2010 for short positive and negative responses in task-oriented dialogues in Polish; Prieto et al. 2013 for double negation in Catalan and Spanish). In addition, intonation has also been shown to interact with syntax in the interpretation of

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5 The Discourse Completion Task is an inductive method which has been applied for many years in research on pragmatics and sociolinguistics, and also recently on prosody, with good results (e.g., Prieto and Roseano 2010).

double negation associated with n-word answers to negative wh-questions (Espinal and Prieto 2011).

3 Experiment 1

The goal of Experiment 1 is to experimentally test whether *yes*-answers to negative *yes/no*-questions in Catalan are perceived as ambiguous by Catalan native speakers when prosody and gesture are not available. In this task, we administered a written questionnaire (Experiment 1) to a group of 30 participants. They were asked to rate *yes*-answers to *yes/no*-questions as either confirming or contradicting the proposition in the question.

3.1 Methodology

3.1.1 Participants

A total of 30 Central Catalan speakers (24 women, 6 men; mean age = 22.35; stdev = 4.70) participated in the experiment. All participants were undergraduate students from the Universitat Autònoma de Barcelona. Catalan dominance was 75.8% (stdev = 17.03) according to the participants' own reports of the estimate percentage of use of Catalan per day.

3.1.2 Materials

The questionnaire used in Experiment 1 evaluated the effects of polarity of the question (positive vs. negative) and the role of the question marker *que* heading *yes/no*-questions (presence vs. absence) in the interpretation of *yes*-answers to such questions in Catalan (see footnote 2). The questionnaire consisted in a total of 12 question-answer pairs (2 polarity conditions (positive vs. negative) × 2 *que* conditions (presence vs. absence) × 3 question items). Appendix 1 contains the full list of 12 items contained in this questionnaire.

3.1.3 Procedure

Thirty participants responded individually and in a quiet environment to 12 written question-answer pairs consisting of a *yes/no*-question and a *yes*-answer.

Participants were told to read each question-answer pair and indicate, using a Likert (1–5) scale, what degree of certainty they had, in the light of the answer, about whether the subject of the question (i.e., the mother, the student or the plumber, in the data contained in Appendix 1) had accomplished the action in the question. The experiment lasted approximately 10 minutes. A total of 360 responses were obtained (30 participants × 12 items = 360).

3.1.4 Measures and analyses

The Likert scale responses on the certainty of the answer were analyzed using a Generalized Linear Mixed Model (GLMM) using IBM SPSS Statistics 20.0 (IBM Corporation, 2011). We fitted the data with Response (as per de Likert scale responses) as the dependent variable, and included Polarity (negative vs. positive questions) and Question Marker (with *que* vs. without *que*) as fixed factors. Both Subject and Items were set as random factors.

3.2 Results

Figure 1 shows the distribution of the responses obtained for the written questionnaire according to their interpretation in the Likert scale (1 – Absolutely not; 5 – Absolutely yes). The data are separated by two conditions, namely Polarity (positive vs. negative questions) and Question Marker (with *que* vs. without *que*). The distribution of responses shows that Catalan native speakers clearly distinguish between *yes*-answers to positive questions from *yes*-answers to negative ones. The former are mostly interpreted as conveying a strong assertive answer, no matter whether the question is preceded by a question marker *que* or not. By contrast, the latter are interpreted with a high degree of doubt, which is made explicit by the distribution of the answers across the five possibilities of the Likert scale.

A GLMM analysis was run, with the Response as the dependent variable. The fixed factors were Polarity (positive vs. negative questions) and Question Marker (with *que* vs. without *que*), and Subject and Item were set as random factors. A main effect of Polarity was found ($F(1,356) = 103.21$, $p < .001$), but no main effect of Question Marker ($F(1,356) = 0.03$, $p = .86$). Post-hoc analyses revealed no interaction between Polarity × Question Marker ($F(1,356) = 0.03$, $p = .86$), showing that the presence or absence of question markers has the same effect over participants' responses, both as responses to positive or negative questions.
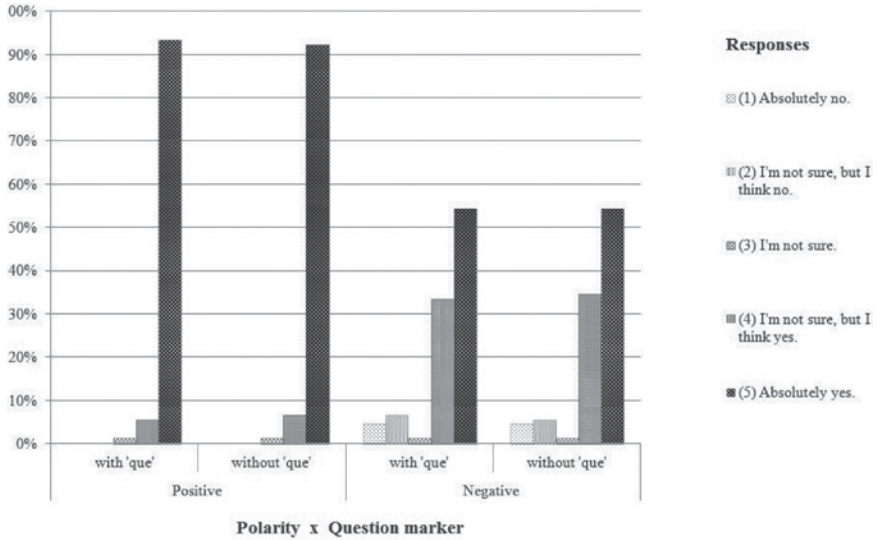
Fig. 1: Distribution of the responses according to their degree of certainty in the 1 to 5 Likert scale.

These results demonstrate that *yes*-answers to negative *yes/no*-questions are not always assertive and confirmatory, as expected from the lexical meaning of 'yes', but rather display a wide distribution in the degree of certainty. They also indicate that further research is needed in order to assess the positive vs. negative questions asymmetry with respect to the interpretation of *yes*-answers.

In the next section, we present the design and results of Experiment 2, which has the goal of assessing the combined role of prosody and gesture in the interpretation of *yes*-answers to negative *yes/no*-questions.

4 Experiment 2

We conducted a perception experiment with native Catalan speakers through an audio-visual online questionnaire. A group of 40 Catalan listeners rated *yes*-answers to *yes/no*-questions as either confirming (i.e., asserting a salient propositional discourse referent), or contradicting (i.e., rejecting an assertion about a salient propositional discourse referent). In addition, participants had to evaluate the naturalness of the *yes*-answer.

4.1 Methodology

4.1.1 Participants

A total of 40 Central Catalan speakers (34 women, 6 men; mean age = 22.95; stdev = 4.22) participated in the experiment. As in Experiment 1, all participants were undergraduate students from the Universitat Autònoma de Barcelona. Catalan dominance was 70.62% (stdev = 21.47) according to the participants' own reports of the estimate percentage of use of Catalan per day.

4.1.2 Audio-visual recordings

To investigate the intonation patterns and gesture(s) Catalan speakers use when uttering a *yes*-answer with a contradiction reading, we first carried out a production study by means of a DCT (Blum-Kulka et al. 1989; Billmyer and Varghese 2000; Félix-Brasdefer 2010), with four native speakers of Catalan. The native Catalan speakers were confronted with two types of positive and negative questions: one that favored a contradiction and another one that prompted a positive answer to a confirmation-seeking question.[6] Although we requested the participants to respond a bare *yes* in every situation, we also asked them to try to sound and act in a natural way. We obtained a total of 24 *yes*-answers (4 speakers × 6 contexts).

The answers were recorded in a quiet room at the Universitat Pompeu Fabra with a professional digital video camera (Panasonic AG-HMC41). The speakers faced the camera and had a uniform white background behind. Taking into account that head movements and facial expressions were relevant at the time of producing *yes*-answers both with a confirmation and a contradiction reading, the head and the upper part of the body were recorded. The video recordings were digitized at 25 frames per second, with a resolution of 720 × 576 pixels. The sound was sampled at 44,100 Hz using 16-bit quantization.

The answers obtained in this task were acoustically analyzed with Praat (Boersma and Weenink 2008) and coded prosodically following the Cat_ToBI system (Prieto 2014). It was found that *yes*-answers in contradiction contexts were most often produced with a L+H* L!H% intonation pattern, whereas *yes*-answers

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6 The former were questions of the sort contained in Experiment 2. The latter were questions that prompted an answer that was related to the speaker's personal facts (e.g., to a speaker called Maria: 'Is your name Maria?').
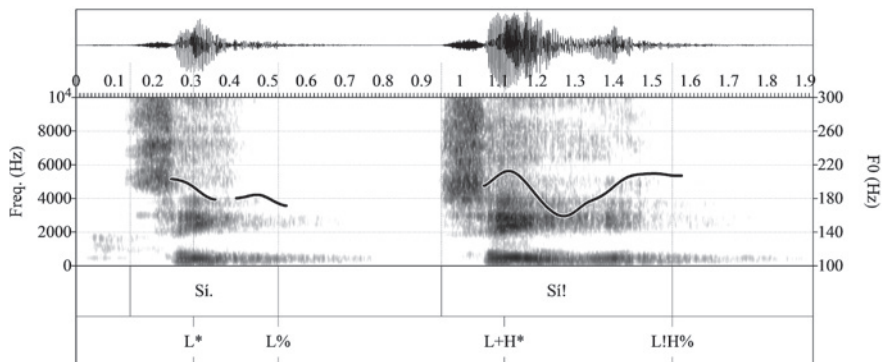
Fig. 2: Spectrograms and F0 contours of Catalan *sí* answer in confirmation contexts (left) and contradiction contexts (right).

to confirmation-seeking questions were produced with a L* L% intonation contour. Figure 2 displays an example of each intonation contour.

With respect to gesture, *yes*-answers were analyzed with ELAN (an open source tool used for annotating and aligning transcriptions with video data). We used the guidelines in Allwood et al. (2005) and McNeill (1992) to code gestural features. It was found that *yes*-answers in confirmation contexts were performed with head nods or slight nods (100% of the cases) and slight eyebrow rising (50%). In contradiction contexts, *yes*-answers were associated with more intense nodding (100% of the cases) and eyebrow rising (50%), wide hand/arm movements (100%), as well as with shoulder shrug (75%). Figure 3 (below) shows an example of the typical gesture behavior for each of the two kinds of responses. In essence, contradiction *yes*-answers use a set of gestural features (namely wide shoulder shrug movements and arm opening gestures) which would be marked and non-felicitous as confirmation *yes*-answers.

The materials obtained with this production task were used as materials for our perception experiment.

4.1.3 Materials for the perception experiment

The main aim of perception Experiment 2 was to test whether intonation and gesture had any effect at the time of interpreting *yes*-answers to negative *yes/no*-questions in Catalan. Out of the 6 target *yes* utterances produced by each of the 4 subjects in the production task (see section 4.1.2), we selected the 2 most repre-
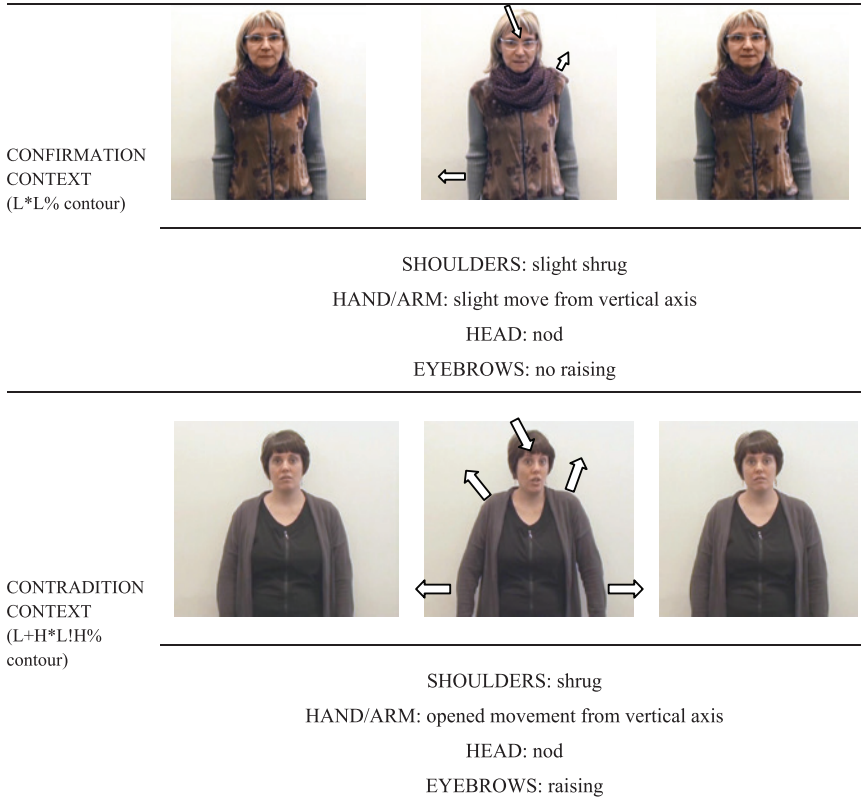
CONFIRMATION
CONTEXT
(L*L% contour)

SHOULDERS: slight shrug

HAND/ARM: slight move from vertical axis

HEAD: nod

EYEBROWS: no raising

CONTRADITION
CONTEXT
(L+H*L!H%
contour)

SHOULDERS: shrug

HAND/ARM: opened movement from vertical axis

HEAD: nod

EYEBROWS: raising

Fig. 3: Sequence of the typical gestures performed during Catalan *sí* answers in confirmation contexts (top) and contradiction contexts (bottom).

sentative and prototypical with respect to prosody (one with a L+H* L!H% contour and one with a L* L% contour) and gesture (see Figure 3) for each speaker, for a total of 8 audio files and 8 video files. We used Adobe Premiere CS5 in order to segment the files and obtain 8 video files, from which we extracted 8 corresponding audio files (4 subjects × 2 contours × 2 conditions). These 16 audio and video files were used as stimuli in Experiment 2. Appendix 2 contains the full list of items contained in the online questionnaires.

The questions in the question-answer pairs were audio-recorded by 4 different native Catalan speakers with a PMD660 Marantz professional portable digital recorder and a Rode NTG2 condenser microphone, and were segmented with SoundForge (a software program used for editing audio data).

4.1.4 Procedure

Forty participants responded individually to an online questionnaire generated with SurveyGizmo (an open source software used to generate different kinds of questionnaires that can be distributed online) containing a set of 16 mini-dialogues consisting of a *yes/no*-question and a *yes*-answer. Each participant was asked to respond to 16 mini-dialogues of identical sort to the ones used in Experiment 1. In Experiment 2, however, the questions were presented in audio condition, where as the answers were presented either in audio-only (AO) or in audio-visual (AV) condition.

To avoid effects of data repetition, we designed 4 different online questionnaires. We tested several conditions, isolated and combined. On the one hand, how the Polarity of the question (positive vs. negative) and the Question Marker *que* (presence vs. absence) affected the interpretation of *yes*-answers to *yes/no*-questions in Catalan. On the other hand, how marking – intonation (L+H* L!H% vs. L* L%) or a combination of intonation and gesture (L+H* L!H% plus contradiction gesture vs. L* L% plus confirmation gesture) – in combination with modality (AO vs. AV) affected these same *yes*-answers. Each of the 4 different online questionnaires contained all possible combinations ($16 = 2 \times 2 \times 2 \times 2$) of the 2 values of each of the 4 fixed factors (polarity of the question, question marker *que*, audio-visual marking, and modality condition), making sure that the 4 speakers appeared in the production of at most 4 different items. The difference across the 4 questionnaires lied in the fact that they were designed by a random combination of the random factors 'topic of the question' (i.e., 'registration', 'mother', and 'plumber'), 'speaker of the question' (speaker 1, 2, 3, and 4), and 'speaker of the answer' (speaker A, B, C, and D). In order to avoid potential audio-visual effects on the perception of the answers, participants were presented first with the AO condition (block 1) and then with the AV condition (block 2) in the 4 questionnaires.

Participants were instructed to listen to each question and to listen to or to watch each *yes*-answer (depending on the condition) as many times as they wanted. Then, they were asked to rate, using a Likert (1–5) scale, two aspects related to their interpretation of the answer: (i) the degree of certainty they had, in the light of the answer, about whether the subject of the question had accomplished the action in the question, and (ii) the degree of naturalness of the perceived *yes*-answer as a reply to a negative question.

We obtained a total of 640 responses for perceived certainty (first Likert scale) and 640 for estimated naturalness (second Likert scale) (10 subjects $\times$ 4 questionnaires $\times$ 2 questions with different polarity $\times$ 2 questions with/without *que* $\times$ 2 audiovisual marking $\times$ 2 modality conditions).

4.1.5 Measures and analyses

The 2 Likert scale responses (certainty and naturalness of the answer) were analyzed with a Generalized Linear Mixed Model (GLMM) using IBM SPSS Statistics 20.0. In both GLMM analyses, the fixed factors were Polarity (positive vs. negative questions), Marking (confirmation intonation/gesture vs. contradiction intonation/gesture), Modality (AO vs. AV presentation), and Question Marker (with *que* vs. without *que*). Subject and Item (a random combination of 'speaker of the question', 'speaker of the answer', and 'topic of the question') were set as random factors.

4.2 Results

4.2.1 Results of the certainty responses

A GLMM analysis was run with Response as the dependent variable. The fixed factors were Polarity (positive vs. negative questions), Marking (confirmation intonation/gesture vs. contradiction intonation/gesture), Modality (AO vs. AV presentation), and Question Marker (with *que* vs. without *que*). Subject and Item were set as random factors. A main effect of Polarity was found ($F(1,624) = 8.68$, $p < .005$), as well as a main effect of Marking ($F(1,624) = 27.98$, $p < .001$), but no main effects of Question Marker ($F(1,624) = 0.11$, $p = .74$) and Modality ($F(1,624) = 0.10$, $p = .75$) were obtained. Post-hoc analyses revealed a statistically significant interaction between Polarity × Marking ($F(1,624) = 16.77$, $p < .001$), indicating that the effect of intonational and gestural marking is different depending on whether the *sí* 'yes' is an answer to a positive or to a negative question. A significant interaction between Modality × Marking ($F(1,624) = 22.71$, $p < .001$) was also found, showing that the effects of Marking (confirmation intonation/gesture vs. contradiction intonation/gesture) are different depending on the modality of presentation (AO vs. AV). The statistically significant interactions of Experiment 2 (the AO and AV experiment) are graphically presented in Figures 4 to 7.

Figure 4 shows the average of the degree of certainty that our informants reported (*y*-axis) in relation to the interpretation of *yes*-answers both to negative and positive questions (*x*-axis). The results graphically show the interaction between Polarity and Marking, illustrating the asymmetry between marked vs. unmarked responses to negative and positive *yes/no*-questions. While y*es*-answers to positive questions are interpreted similarly regardless of their Marking (i.e., both confirmatory vs. contradictory intonation/gestures), *yes*-answers to
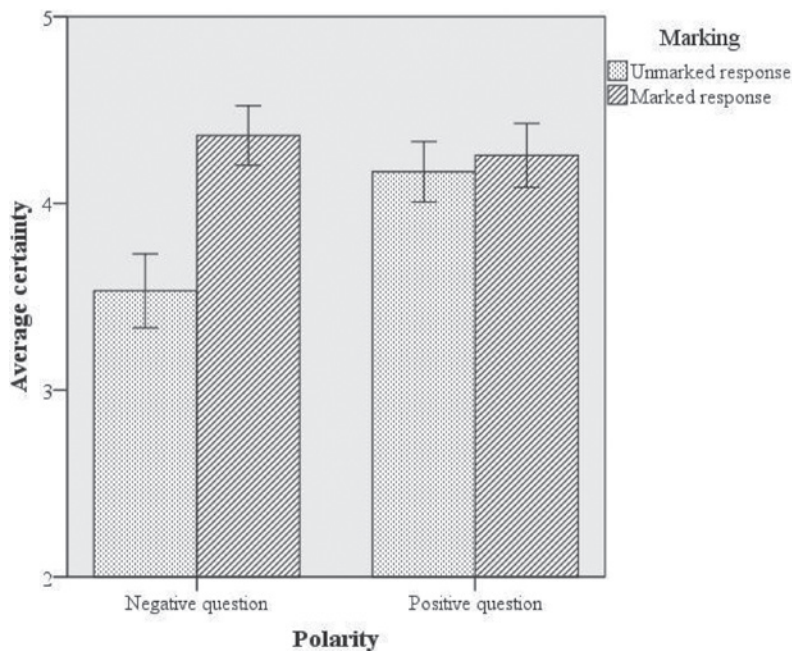
Fig. 4: Average degree of certainty as a function of Polarity of the question and Marking.

negative questions are ranked higher in the certainty scale when they are pro-
duced with contradictory intonation/gestures, showing that the marking condi-
tion (i.e., intonation, or a combination of intonation and gesture) is higher when
answering negative questions. As expected, the results in Figure 4 are compatible
with the findings in Experiment 1 (i.e., speakers expressed doubt when the an-
swer *sí* 'yes' is produced with an unmarked intonation).

On the other hand, when we consider the interaction between Modality and
Marking of the answer with respect to the degree of certainty, significant results
are obtained. We shall focus on the results of *sí* answers to negative questions.
Figure 5 shows the average degree of certainty (1 to 5 scale) to negative ques-
tions as a function of Modality (AO vs. AV, *x*-axis) and Marking (Unmarked =
confirmation intonation/gesture vs. Marked = contradiction intonation/gesture).
The results show that *yes*-answers to negative *yes/no*-questions are interpreted
as inducing less doubt in the AV modality than in the AO. In the AV modality,
marking (consisting of a combination of intonation and gesture) facilitates the
interpretation of *yes*-answers towards the 5-degree in the Likert scale. This re-
sult is related to the incremental nature of the AV modality: gesture enhances
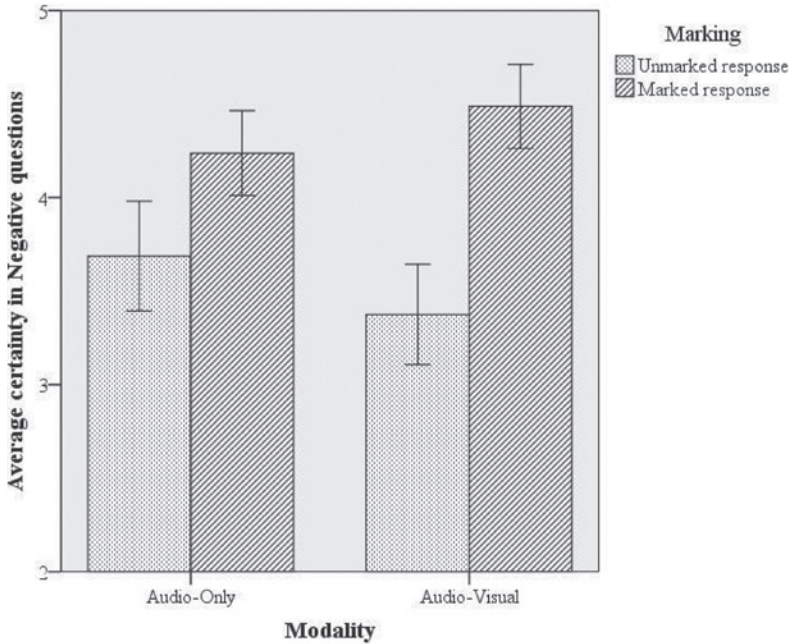the effect of intonation in the interpretation of *yes*-answers to negative *yes/no-*

Fig. 5: Average degree of certainty to negative questions as a function of Modality and Marking.

questions. On the other hand, in the AO condition, intonation alone helped in the interpretation of the positive answer to a negative question to a lesser extent.

4.2.2 Results of the naturalness responses

In this section we analyze a complementary measure to the response scale, namely the naturalness responses. A GLMM analysis was run with naturalness as the dependent variable. The fixed factors were again Polarity (positive vs. negative questions), Marking (confirmation intonation/gesture vs. contradiction intonation/gesture), Modality (AO vs. AV presentation), and Question Marker (with *que* vs. without *que*). Subject and Item were set as random factors. A main effect of Marking was found ($F(1,624) = 156.99$, $p < .001$), together with a nearly significant effect of Modality ($F(1,624) = 3.7$, $p = .052$), but no main effects of Polarity ($F(1,624) = 1.22$, $p = .27$), nor Question Marker ($F(1,624) = 2.36$, $p = .12$) were obtained. Paired post-hoc analyses revealed a statistically significant interaction between Polarity × Marking ($F(1,624) = 16.90$, $p < .001$), indicating that the effect
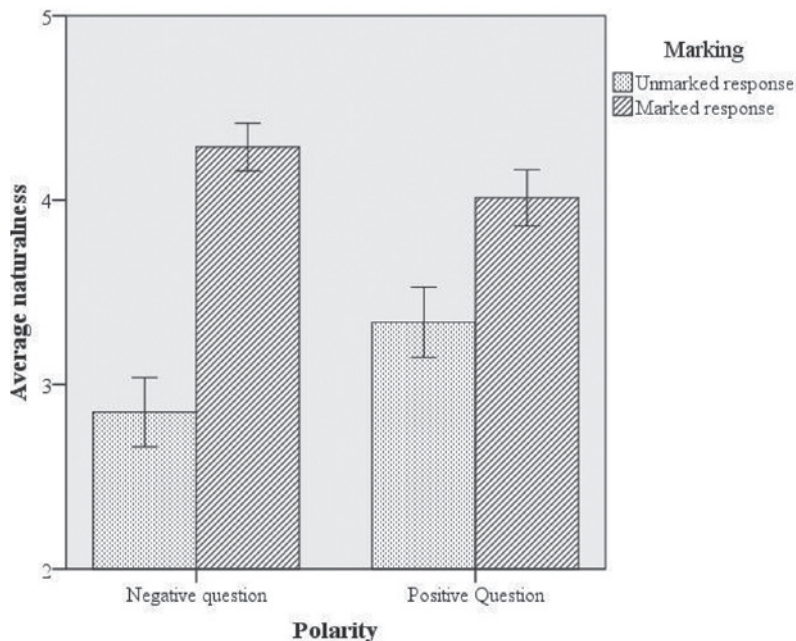
Fig. 6: Average degree of naturalness as a function of Polarity of the question and Marking.

of intonational and gestural marking is different depending on whether the *sí* is an answer to a positive or to a negative question. Significant interactions between Modality × Marking ($F(1,624) = 16.90$, $p < .001$), and between Polarity × Marking × Modality ($F(1,624) = 4.76$, $p < .05$) were also found, showing that the effects of Marking (confirmation intonation/gesture vs. contradiction intonation/gesture) are different depending on the modality of presentation (AO vs. AV) and on the interaction between polarity and marking.

Figure 6 shows the average degree of naturalness (1 to 5 scale) as a function of the Polarity of the question (negative vs. positive) and Marking (confirmation intonation/gesture vs. contradiction intonation/gesture). We can observe an interesting correlation between the results shown in Figure 6 and in Figure 4, the difference being that the former evaluates the degree of certainty and the latter evaluates the degree of naturalness of the answer. Regardless of the polarity of the question, marked *yes*-answers are perceived as approaching the maximum degree of naturalness. We observe that marked *yes*-answers are slightly less adequate in relation to positive questions. By contrast, *yes*-answers to positive questions with an unmarked intonation are perceived as more natural than similar answers to negative questions. The results prove that there is an
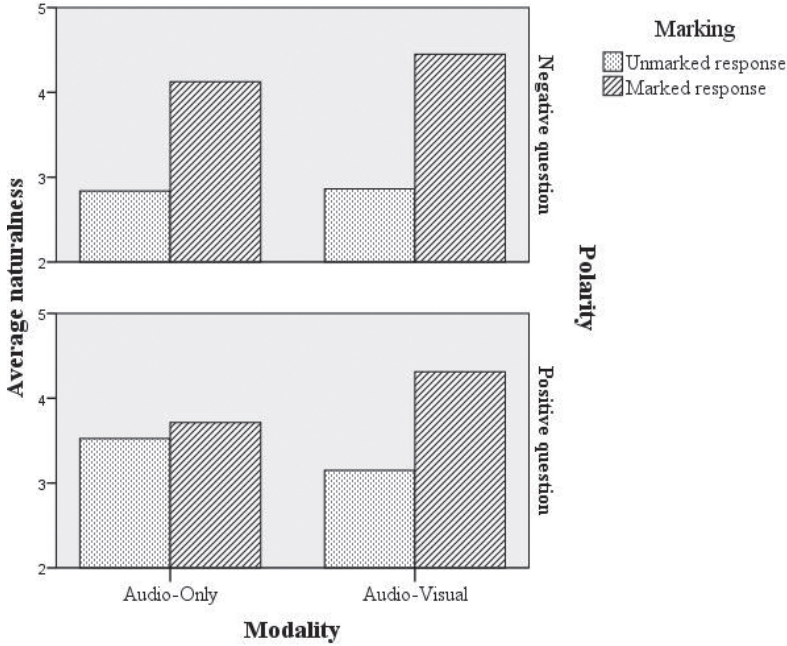
Fig. 7: Average degree of naturalness as a function of Polarity, Modality and Marking.

asymmetry in the interpretation of *yes*-answers to positive and negative *yes/no*-questions in relation to marking both in the evaluation of certainty and of naturalness.

Figure 7 illustrates the interaction between Polarity, Modality and Marking. This figure shows the average degree of naturalness (1 to 5 scale) as a function of Polarity (positive questions, bottom panel; and negative questions, top panel), Modality (AO vs. AV) and Marking (confirmation intonation/gesture vs. contradiction intonation/gesture). Focusing on the negative question panel, the results show that both in the AO and AV condition, contradictory/marked *yes*-answers to negative questions are perceived as more natural than the unmarked ones. These results are even better in the AV than in the AO condition. Unmarked *yes*-answers are perceived as slightly more natural in the AO condition than in the AV. The results of Figure 7 show the same tendency as the results of Figure 5 in the AV condition, namely the degree of certainty and naturalness is more clear-cut with marked responses than with unmarked ones. Although in Figure 5 unmarked responses in the AO condition are perceived with a similar degree of certainty to marked ones, Figure 7 shows that unmarked responses are perceived as less natural than marked ones.

5 Discussion and conclusions

Experiment 1 demonstrated that informants do not easily understand *yes*-answers to negative *yes/no*-questions as assertive or confirmatory. These results motivated Experiment 2, which was designed to test whether the degree of certainty and naturalness in the interpretation of *yes*-answers to negative *yes/no*-questions improved at the time prosodic and gestural factors played a role in the speech act. The results of Experiment 2 confirmed the findings in Experiment 1: with unmarked intonation and gesture, *yes*-answers to negative *yes/no*-questions induced doubt among speakers, who did not assign them top values in the certainty Likert scale (see Figure 4). It was also found that the AV modality (in contrast to the AO modality) ameliorated this situation, that is, the addition of intonation and gesture facilitated the interpretation of *yes*-answers (see Figure 5). These responses were judged not only with a high degree of certainty but also as more natural when uttered with a contradiction intonation and gesture (see Figures 6 and 7). Hence, our results support the claim that prosody and gesture play a crucial role in the interpretation of *yes*-answers to *yes/no*-questions in a polarity-based language such as Catalan.[7]

With respect to *yes*-answers, we claim that *sí* is not ambiguous. It is always the head of Force⁰ (Rizzi 1997; Moro 2003), and semantically corresponds to an ASSERT operator (Krifka to appear, 2013): it asserts the most salient propositional elliptical discourse referent, which either corresponds to *p* (i.e., the IP of the question) or to ¬*p* (i.e., the NegP of the question). The relevant structure is represented in (9), with *sí* sitting at the head of Force⁰. The difference between (9a) and

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7 It seems, however, that prosody may also be important for the interpretation of *yes*-answers in a language such as Russian where, according to our informants, it is not only possible to contradict a *yes/no*-question by means of the answer *da niet* + *verb* (literally: 'yes no' + verb) – as expected in a truth-based language – but also by uttering *da* 'yes' with special intonation. In Mandarin, a truth-based language, our informants also report the possibility of answering negative *yes/no*-questions with the combination of *shi* 'yes' and several particles (-*a*, -*ba*, -*ma*) that convey confirmation, uncertainty, disagreement or surprise. The use of a denial particle *ba* in combination with *da* 'yes' and *nu* 'no' has been also described for a polarity-based language such as Romanian (Farkas and Bruce 2010; Krifka to appear). It has also been observed earlier in the paper that lexical selection may fulfil the role that we here attribute to prosody and gesture (e.g., French *si*). Similarly, German has a specific particle *doch*, which means 'yes' in response to a negative question, and which must be used instead of *ja* (Karagjosova 2006; Krifka to appear). Overall these studies suggest that further research must be carried out for a full understanding of the various means that different languages have to express reject/denial/contradiction, and therefore for a full understanding of the difference between truth-based and polarity-based languages.

(9b) has to do with the salient propositional discourse referent that has been elided. The strikethrough line indicates ellipsis of either IP or NegP.

(9) a. [$_\text{ForceP}$ **Force⁰** *sí* . . . [$_\text{IP}$ ~~. . .~~]]
  b. [$_\text{ForceP}$ **Force⁰** *sí* . . . [$_\text{NegP}$ **Neg⁰** *no* [$_\text{IP}$ ~~. . .~~]]]

Yes-answers, then, may have various propositional discourse referents, since they might either respond to a question about *p* (as in (7) above), or to a question about ¬*p* (as in (8) above). The fact that, at the time of interpreting a *yes*-answer, speakers may have access to two propositional discourse referents (either the semantic contents of the IP or the NegP in the question) is even more evident where no polarity particle (i.e., *també* 'too' and *tampoc* 'either') is available, as was the case in the data of our study. This is why in our study *yes*-answers to negative *yes/no*-questions were interpreted as dubious and conceived as unnatural, unless the answer was marked with a special intonation/gesture.

Consider the structures in (10), which we repeat from (9), the only difference being that in (10b), in order to licence a reject/denial/contradiction reading, the symbol √ – for marked intonation and gesture – is superimposed on the whole structure.

(10) a. [$_\text{ForceP}$ **Force⁰** *sí* . . . [$_\text{IP}$ ~~. . .~~]]
  b. √ [$_\text{ForceP}$ **Force⁰** *sí* . . . [$_\text{NegP}$ **Neg⁰** *no* [$_\text{IP}$ ~~. . .~~]]]

The interpretation of (10a) is: ASSERT(*p*), whereas the interpretation of (10b) is: REJECT[ASSERT(¬*p*)]. The operator REJECT is visible at the PF-component by a special prosody, and at the grammar-cognition interface by a special gesture.

Our results show that if these special prosody and gesture are not available, that is, with an unmarked intonation and gesture, the assertive *yes*-answer is perceived as inappropriate to a salient negative discourse referent, with an outcoming doubt in the degree of certainty and an outcoming unacceptability in the degree of naturalness. If the *yes*-answer is uttered with marked intonation and gesture, by contrast, it cancels the meaning of the negative marker in Neg⁰. In other words, prosody and gesture seem to indicate that the *sí* 'yes' in Force⁰ rejects the *no* 'not' in the discourse referent, thus eliminating the polarity interpretability conflict depicted in (10b) above. It is only by associating marked prosody and gesture to the *yes*-answer that the hearers find a bare *yes* not only a relevant answer, but also an answer that expresses a high degree of certainty and is interpreted with a high degree of naturalness on the side of the hearer. That is, with marked intonation and gesture, the *yes*-answer is interpreted as a reject/denial, cancelling the negative meaning that corresponds to ¬*p*.

The results in Figure 1 show that with only written information at hand, participants hesitate in a significant way at the time of interpreting *yes*-answers to negative *yes/no*-questions, and we interpret this result as reflecting uncertainty with regard to the fact that they are responding to a question about p or about $\neg p$. Hence, they show a good amount of dispersion in their responses (i.e., doubt) when evaluating how the *yes*-answer is interpreted.

In Figure 4, column 1 shows that participants evaluate unmarked *yes*-answers to negative *yes/no*-questions with a low degree of certainty with respect to unmarked responses to positive questions (as in Figure 1). Again, we interpret this result as reflecting the hearer's uncertainty about whether *sí* 'yes' is an answer to a question about p (i.e., IP) or to a question about $\neg p$ (i.e., NegP). Column 2, by contrast, shows that a marked intonation, or the combination of a marked intonation and gesture allow hearers to decide that the negative question is actually a question about $\neg p$, characteristic of languages with middle negation, and that the *yes*-answer is denying the salient negative proposition in the question. This reject/denial/contradiction reading is an interpretive inference that, in our data, is possible when syntax interacts with intonation and gesture: only a L+H* L!H% intonation with its associated gesture guarantee that the *yes*-answer can be interpreted, with a high degree of certainty, as cancelling the negative accessible proposition.[8] We have shown that prosody and gesture is what guarantees the interpretation of a meaning cancelling operation (Force^0 denying Neg^0), since marked *yes*-answers to negative *yes/no*-questions are the ones that are perceived as more natural, even more than the corresponding *yes*-answers to positive questions (see Figure 6). When intonation and gesture are unmarked, *yes*-answers to negative *yes/no*-questions are difficult to interpret (i.e., they are assigned a degree of certainty in the area of doubt 2-3-4 in the 1-to-5 Likert scale) and, in addition, are perceived as not very natural (with rating under 3 in the Likert scale).

A combination of intonation and gesture (i.e., AV inputs) in *yes*-responses interestingly provides the highest degree of certainty on the side of our participants (see Figure 5), thus showing the role of gesture in utterance interpretation. The results of Experiment 2 (see Figures 5 and 7) also indicate that when interpreting *yes*-answers and disambiguating *yes/no*-questions as either negative questions about p or as positive questions about $\neg p$, it is crucial that the grammatical inputs be related with other cognitive systems, particularly, the gesture system (Jackendoff 1997, 2002; McNeill 1992, 2005). If hearers only have AO inputs, the

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8 Independent research carried out in other languages (see footnote 7) seems to indicate that specific lexical items might be an alternative to a special prosody.

degree of certainty assigned to the *yes*-answer is below 4 in unmarked responses. Besides, the results indicate that intonation alone does not really aid in the interpretation of *yes*-answers. By contrast, when the input is in AV modality and, hence, gesture is used, the degree of certainty assigned to the interpretation of the answer increases towards 5 if the response is marked, and towards 3 (i.e., doubt) if the response is unmarked. Likewise, the naturalness of a *yes*-answer to a negative *yes/no*-question is higher in the AV modality. This confirms the idea that gesture, in combination with intonation, is crucial in the process of interpretation of statements.

Our results also support the hypothesis that middle negation is the position where *no* is interpreted by default by our informants of Catalan. That is, negation in this language expresses propositional negation. Therefore, negative *yes/no*-questions are not ambiguous. Our results also support the hypothesis that *yes*-answers are not ambiguous either; as postulated by Krifka (to appear, 2013) *yes* always refers to a salient propositional discourse referent (either *p* or ¬*p*) and asserts its proposition. We conclude that the possibility of interpreting *yes*-answers as rejects is not due to a grammatical ambiguity issue, but rather to a possible interpretation at the level of speech acts, as the output of the interaction between syntax and the prosodic and gesture systems. Our findings also contribute interesting insights on the design of language: syntactic structures interact with other cognitive systems. Further research should allow us to determine the extent of the contribution of gesture in relation to marked intonation and fine-grain the impact of each in the resolution of so-called linguistic ambiguity of negative questions in both polarity-based and truth-based languages.

Appendix 1 – Experiment 1

Ara llegiràs una sèrie de minidiàlegs consistents en una pregunta i una resposta. Encercla la interpretació que donaries a la resposta. [*Now you will read a series of mini-dialogues consisting of a question and an answer. Circle the interpretation you would attribute to the answer.*]

1. –(Que)   (no)   t'   has   matriculat?
    Question marker   not   you   have   registered
    'Have(n't) you registered?'
  –Sí.
    yes
    'Yes'

Com interpretes la resposta? [*How do you interpret the answer?*]

a. Estic segur/a que no s'ha matriculat. [*I'm sure s/he has not registered.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si s'ha matriculat o no. [*It is not clear to me whether s/he has registered or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que s'ha matriculat. [*I'm sure s/he has registered.*]

2. –(Que)   (no) ha   arribat, el   lampista?
    Question marker not   has   arrived   the   plumber
    'Has(n't) the plumber arrived?'
    –Sí.
    yes
    'Yes'

a. Estic segur/a que no ha arribat. [*I'm sure s/he has not arrived.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si ha arribat o no. [*It is not clear to me whether s/he has arrived or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que ha arribat. [*I'm sure s/he has arrived.*]

3. –(Que)   (no) ha   arribat, ta   mare?
    Question marker not   has   arrived   your mother
    'Has(n't) your mother arrived?'
    –Sí.
    yes
    'Yes'

a. Estic segur/a que no ha arribat. [*I'm sure s/he has not arrived.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si ha arribat o no. [*It is not clear to me whether s/he has arrived or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que ha arribat. [*I'm sure s/he has arrived.*]

Appendix 2 – Experiment 2

NB: The symbol '√' indicates that the answer was uttered with L+H* L!H%. The questions were always presented in audio. The answers were given in audio (Block 1) or in video (Block 2).

Ara sentiràs una sèrie de minidiàlegs consistents en una pregunta (en àudio) i una resposta (en àudio o en vídeo). Com interpretes la resposta? [*Now you will hear a series of mini-dialogues consisting of a question (in audio) and an answer (in audio or in video). How do you interpret the answer?*]

1. –(Que)   (no)   t'   has   matriculat?
   QUESTION MARKER   not   you   have   registered
   'Have(n't) you registered?'
   –(√)Sí.
        yes
        'Yes'

a. Estic segur/a que no s'ha matriculat. [*I'm sure s/he has not registered.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si s'ha matriculat o no. [*It is not clear to me whether s/he has registered or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que s'ha matriculat. [*I'm sure s/he has registered.*]

Valora de l'1 (gens natural) al 5 (completament natural) si et sembla que la resposta a la pregunta és natural. [*Evaluate from 1 (not natural at all) to 5 (completely natural) whether you think that the answer to the question is natural.*]
1
2
3
4
5

2. –(Que)   (no)   ha   arribat,   el   lampista?
   QUESTION MARKER   not   has   arrived   the   plumber
   'Has(n't) the plumber arrived?'
   –(√)Sí.
        yes
        'Yes'

a. Estic segur/a que no ha arribat. [*I'm sure s/he has not arrived.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si ha arribat o no. [*It is not clear to me whether s/he has arrived or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que ha arribat. [*I'm sure s/he has arrived.*]

Valora de l'1 (gens natural) al 5 (completament natural) si et sembla que la resposta a la pregunta és natural. [*Evaluate from 1 (not natural at all) to 5 (completely natural) whether you think that the answer to the question is natural.*]
1
2
3
4
5

3. –(Que)   (no)   ha   arribat,   ta   mare?
     Question marker   not   has   arrived   your   mother
     'Has(n't) your mother arrived?'
   –(√)Sí.
      yes
      'Yes'

a. Estic segur/a que no ha arribat. [*I'm sure s/he has not arrived.*]
b. Dubto, però m'inclino cap al 'no'. [*I doubt, but I interpret it towards 'no'.*]
c. No em queda clar si ha arribat o no. [*It is not clear to me whether s/he has arrived or not.*]
d. Dubto, però m'inclino cap al 'sí'. [*I doubt, but I interpret it towards 'yes'.*]
e. Estic segur/a que ha arribat. [*I'm sure s/he has arrived.*]

Valora de l'1 (gens natural) al 5 (completament natural) si et sembla que la resposta a la pregunta és natural. [*Evaluate from 1 (not natural at all) to 5 (completely natural) whether you think that the answer to the question is natural.*]
1
2
3
4
5

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