Prosody is adding what?
Echo questions are not a thing[*]

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Abstract   While *echo questions* (EcQs) are often said to be identified by their prosodic properties, there is no empirical study actually supporting such claim. Focusing on *wh*-utterances we provide results from a production study, a classifier, and a perception study to argue that prosody is not a reliable cue to identify an inquisitive utterance as EcQ. We also offer a model that unifies the semantics of utterances inquiring about what has just been said (EcQs) and utterances inquiring about 'non-discursive' facts, *information seeking questions* (InfQs), while keeping the interpretation of the utterance true to form.

Keywords: echo questions, prosody, semantics, discourse models, dynamic update

1   What are echo questions?

In this paper we understand the term *echo question* to refer to inquiries about what has just been said and constrain ourselves to utterances with wordings that can also have an *information seeking* interpretation (InfQ). These are what we call EcQs below. There are certainly other means to ask about what has just been said, e.g., some languages may make use of particles. We briefly address this in §4.

In English, as well as other languages, EcQs are stereotypically illustrated with non-fronted *wh*-words, (1), contrasting with the standard *wh*-fronted strategy stereotypically used for information seeking questions, (2):

(1)   A: I ate ostrich. / I ate #$!@%.

   B: You ate what?   Stereotypical EcQ

   ≈'What have you just said that you ate?'

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(2) A: I went to the new restaurant.

  B: What did you eat? Stereotypical InfQ

(1B) does not ask what A ate but rather what they said they ate: it is a question about a *discursive fact*. The question may be triggered because the speaker cannot believe what they heard (Ec(ho)Ep(istemic)), or because they couldn't actually properly hear part of what was said (Ec(ho)Per(ception)).

Much of the literature on EcQs tries to understand how to derive the overall meaning of (1B) in addition to their syntactic properties, since non-fronted *wh*-inquires have traditionally been tied only to EcQs and disregarded as InfQs (but see Pires & Taylor 2007; Biezma 2020). Current theories argue that the syntax-semantics of EcQs is different from that of InfQs and support for such theories comes from claims about differences in their respective linguistic cues. Different proposals vary on how they model the claimed differences: some theories argue for a special (silent) complementizer at LF and/or a special semantics to the *wh*-word (see, e.g., Sobin 1990, 2010; Dayal 1996; Ginzburg & Sag 2001; Artstein 2002; Sudo 2007; Beck & Reis 2018). One of the cues traditionally used is word-order, but while EcQs stereotypically have a non-fronted *wh*-word, as in (1B), and many approaches constrain themselves to these cases (see e.g. Sudo 2007; Beck & Reis 2018), it is important to notice that all strategies available to inquire about non-discursive facts are also available to inquire about what has just been said (Biezma 2020): polar- and *wh*-interrogatives (PolInts and WhInts respectively), as well as declaratives with a final rise (RDecs) and with a *wh*-word (WhDecs), can all be EcQs:

(3) A:I ate ostrich. (4) A:Did you eat ostrich?

  B_1:You ate what? WhDec B_1:Did I eat ostrich? PolInt

  B_2:What did you eat? WhInt B_2:#I eat ostrich? RDec

  B_3:You ate ostrich? RDec (5) A:Who ate ostrich?

  B_4:# Did you eat ostrich? PolInt   B:Who ate what?

While the stereotypical EcQ has a non-fronted *wh*-word, an account of EcQs needs to also explain how we obtain the echo-interpretation in other clause types, since both interrogatives, either polar or *wh*-interrogatives, (see (4B) and (3B)) as well as declaratives, either with a final rise (($3B_3$); see e.g. Gunlogson 2003) or with a *wh*-word (($3B_1$); see Biezma 2020) can have both an InfQ and an EcQ interpretation.[1]

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1 Rising declaratives (RDecs) in Gunlogson's work and much work after her are declaratives, not interrogatives, and inquisitivity is the result of epistemic uncertainty signaled by prosody. In this way, Gunlogson's analysis keeps the interpretation of the utterance true to form. The same path is followed in Biezma 2020 in analyzing non-fronted *wh*-utterances as declaratives and deriving inquisitivity as a byproduct of the dynamic context update.

Accounts arguing for a different semantics for EcQs and InfQs tied to a particular word-order are bound to leave unexplained (3)-(5) and are, thus, not satisfactory. Once we consider the term *echo question* as an umbrella term referring to the interpretation of an inquisitive utterance as asking about what has just been said, and not referring to a particular clause type, the research question becomes how to derive the echo-effect across clause-types. Our focus will be on WhInts and WhDecs.

Prosody is also a factor traditionally claimed to determine whether an utterance is an EcQ or an InfQ, and to justify a difference in the semantics. However, claims regarding the importance of prosody in triggering and echo or an information seeking interpretation have not been properly investigated. Hence, claims in the literature arguing for a difference in the semantics between EcQs and InfQs based on differences in the acoustic signal lack empirical support.

In this paper we investigate whether prosodic cues are reliable to trigger an echo or an information seeking interpretation, and justify a different semantics for the two interpretations. Following Repp & Rosin 2015, we include both EcEp and EcPer because prosodic differences may be stronger within EcQs than in comparison to InfQ. In §2, we present results from a production study, a classifier, and a perception study showing that prosody does not accurately predict the three flavors of interpretation. In §3 we propose a unified semantics for echo and information seeking interpretations and derive their differences solely from considerations regarding where in the discourse utterances are placed.

2 Does prosody predict the interpretation?

It is often claimed that the prosody of EcQs is necessarily different from that of InfQs (see Artstein 2002; Bartels 1999; Bolinger 1987; Beck & Reis 2018). In the formal semantics literature, EcQs are said to be identified by having a complex pitch accent, L+H*, and a final rising contour H-H% (e.g. Bartels 1999; Artstein 2002). In Artstein's (2002) proposal, for example, the prosodic form of the utterance identifies it as an EcQ and links it to the previous utterance: all parts of the utterance are given (and deaccented) with only the *wh*-word focused. This has the effect of linking the utterance to the prior discourse, which makes the *wh*-word act as an anaphoric pronoun. The prosodic make-up of EcQs would then indicate a different semantics. While similar claims are often repeated for different languages, empirical studies have not found categorical differences for EcQs and InfQ, (see, e.g., preliminary results in Repp & Rosin 2015 for German and Hu 2002 for Standard Chinese).

Other proposals argue that the difference in the interpretation is at the syntax-semantics interface (see e.g., Beck & Reis 2018),[2] or encoded in a different relation

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2 For German, Beck & Reis (2018) claim (based on introspection) that the *wh*-word prosody is different between EcQs and InfQs. Focusing on non-fronted *wh*EcQs, Beck & Reis (2018) develop an analysis

to the previous utterance (see Ginzburg & Sag 2001).

Here, we investigate whether there is a reliable prosodic difference between EcQs and InfQs that would support current theories of EcQs. We extend Repp & Rosin's (2015) empirical studies on German who investigated f0-excursion, duration, and intensity between indignant and repeat.info in non-fronted *wh*-EcQs and InfQs. We extend this work by comparing two word orders (*wh*-fronted and *wh*-non-fronted), including a phonological analysis, and by adding a perception perspective.

2.1 Experiment 1: Production

2.1.1 Methods

Participants
Twenty-four native speakers of North American English (18-35 years, average = 25.2 years, SD = 5.5 years, 12 female, 12 male) with normal or corrected-to-normal vision participated for a small fee. They were recruited using Prolific (www.prolific.co). None of them was aware of the goal of the experiment. Informed consent was obtained from every participant.

Materials
We constructed 24 *wh*-sentences with three contexts licensing each an EcPer, an EcEp or an InfQ interpretation, see (6), manipulated within-subjects (Latin-Square-Design). There were two versions of each *wh*-sentence (7), with the *wh*-word in fronted vs. non-fronted position (manipulated between-subjects).

(6)   Manipulation of context

    a. A: My parents and my brother are on vacation. My parents will come back tomorrow and my brother will come back in #%*#%.   (EcPer context)

    b. A: My parents and my brother are on vacation. My parents will come back tomorrow and my brother will come back in three months . (EcEp context)

    c. A: My parents and my brother are on vacation. My parents will come back tomorrow.   (InfQ context)

(7)   Manipulation of word order

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in which non-fronted *wh*-EcQs are interrogatives containing a *wh*-phrase with narrow focus. Based on assumed prosodic differences, Beck & Reis (2018) argue that the syntax-semantics of (these) interrogatives and of (fronted) *wh*-interrogatives, assumed to be InfQs (WhInt-InfQs), differ: the echos have a phrasal-Q operator related to focus and it is focus that introduces a deictic/anaphoric element in the calculation at the level of alternative semantic values. The *wh*-word is assumed to be narrowly focused. Beck & Reis (2018) argue that the constraint that EcQs follow the utterance they "echo" is derived from independent properties of focus. In this system we are left, however, without an explanation for EcQs with a fronted *wh*-word, i.e., for echo-WhInts.

      a. B: And your brother will come back <u>when</u>?   (*wh*-non-fronted)

      b. B: And <u>when</u> will your brother come back?   (*wh*-fronted)

The *wh*-sentences all had the same number of syllables and same stress pattern, which allowed us to phonetically compare averaged f0-contours.

Procedure
The experiment was presented using PCIbex (Zehr & Schwarz 2018). In each trial the context and embedded target utterance were shown on screen for as long as the participants needed. After reading the context, participants produced the target sentence in the most natural way. They were instructed to re-record the utterance in case they had a slip of the tongue or were not content with the way they produced it. Only the last production was analyzed. Each participant was presented with all 24 experimental items. To avoid order effects, we created six pseudo-randomised lists (separating each item of a given condition by at least one item of another condition). Before the actual experiment, there were two practice trials to familiarize participants with the procedure and to check that their recording device worked properly. The whole experiment lasted approximately 20'-30'.

Data treatment and annotation
We recorded 576 items of which 34 (5.9%) had to be excluded due to slips of the tongue, hesitations, or missing or added words. The productions were annotated at the syllable level using Praat (Boersma & Weenink 2021). F0-tracking errors were removed and the remaining f0-values were processed using ProsodyPro (Xu 2013). Following Repp & Rosin 2015 and Hu 2002, we extracted the constituent durations, and the f0-range and f0-mean of all accented words. Intensity could not be measured due to remote testing. Also, we annotated the pitch accents and boundary tones (cf. Bartels 1999; Artstein 2002), using MAE-ToBI (Beckman, Hirschberg & Shattuck-Hufnagel 2005). The reliability of this annotation was substantial (as determined by an interrater agreement of 76% ($\kappa = 0.7$) on 6% of the data).

2.1.2   Results: Prosodic analyses

The continuous analysis of the f0-contour with ProsodyPro revealed differences in overall f0 across conditions (more strongly in fronted *wh*-words, see right panel of Fig. 1). In both word orders, EcEp showed lower f0 during the *wh*-word, followed by a steeper and greater f0-rise (cf. Hu 2002; Repp & Rosin 2015). The boundary tone ended in the highest f0-value in EcEp and the lowest f0-value in InfQ. EcPer and InfQ also showed differences, but these differences cannot be easily linked to particular constituents in the utterance.
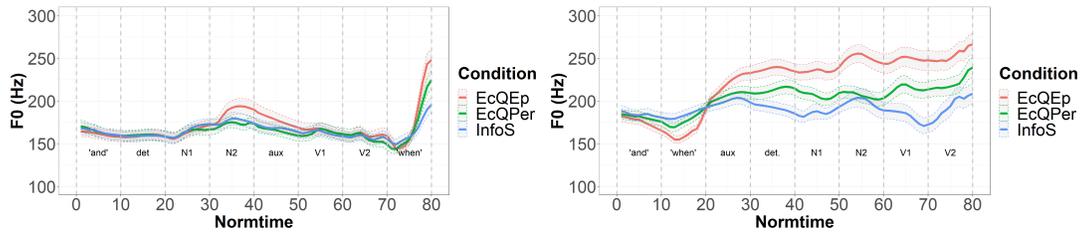
Figure 1   Averaged f0-contours for the two word orders (left panel: *wh*-non-fronted; right panel: *wh*-fronted), as derived from ProsodyPro. Grey lines indicate the 95% confidence interval of the mean.

To locally analyze the differences in overall f0-contour, the f0-range of accents on the *wh*-word and the noun were analyzed using linear mixed-effects regression models with *condition* and *word order* as fixed factors and crossed random intercepts for *participants* and *items* (Baayen, Davidson & Bates 2008). The results showed no interaction between the factors for any of the variables (all p > 0.1), so the data were collapsed across word orders. Significant differences across conditions are summarized below (">" stands for "significantly larger", "=" for "no difference").[3]

- f0-range of the *wh*-word: EcEp > EcPer = InfQ

- duration of the *wh*-word: EcEp > EcPer = InfQ

Analysis of pitch accent types and boundary tones
Pitch accents were analyzed using logistic mixed-effects regression models with the same factors as above. To this end, the accents and boundary tones were converted into binary variables (e.g., L*+H yes/no). There were no effects of *condition* on the accentual realization of the noun. It was accented in more than 90% of the cases in all conditions and word orders.

Wh-words differed across condition: There was a preference for rising *wh*-words throughout, which was expressed differently depending on its position in the utterance. In non-fronted position, in which the *wh*-word was the last word in the utterance, it was most often realized with an L* H-H% (low accent with high boundary tone): 77% in EcEp, 76% in EcPer, and 59% in InfQ. In fronted position, the *wh*-word was most often realized with the rising accent L*+H: 90% in EcEp, 87% in EcPer, and 67% in InfQ. The remaining realizations included H* and L+H*

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3 f0-range of the *wh*-word: EcEp vs. EcPer β=0.90, SE=0.31, df=10.9, t=2.96, p<0.05; EcEp vs. InfQ: β=1.35, SE=0.31, df=10.9, t=4.36, p<0.01; EcEp vs.InfQ: p>0.2. Duration of the *wh*-word: EcEp vs. EcPer: β=78.51, SE=8.27, df=538, t=9.49, p<0.0001; EcEp vs. InfQ: β=78.93, SE=8.29, df=538, t=9.52, p<0.0001; EcPer vs. InfQ: p>0.9.

accents, followed by a low boundary tone in the non-fronted condition. Significant differences across conditions are:[4]

- percentage of L* H-H% in non-fronted position: EcEp = EcPer > InfQ

- percentage of L*+H in fronted position: EcEp = EcPer > InfQ

2.1.3 Results: Automatic classification

This section describes an automatic classification based on the phonetic and phono-logical variables. We tested whether the differences across conditions are large and systematic enough to automatically classify the interpretation. To this end, we trained two classifiers based on random forests (Liaw & Wiener 2002), one for each word order. We made 10 random splits, using 80% of the data for training and 20% for test. This allows us to calculate an average accuracy score that is not dependent on the precise split of the data into training and test. The random forests were trained with the R-package randomForest. The number of trees was set to 1000, mtry (the number of acoustic variables selected at each step) was set to 6. Random forests extract the importance of the individual variables using the Gini-index (Liaw & Wiener 2002). The random forests showed an average accuracy for the *wh*-fronted condition of 67.0% (sd = 6.3%). The accuracy of the *wh*-non-fronted condition was 44.2% (sd = 4.3%), which was considerably lower, but still significantly above chance (33.3%, t(9) = 8.2, p < 0.001).

2.1.4 Discussion

The noun (e.g., *brother* in (7)) was typically accented, irrespective of condition. This speaks against Artstein's (2002) claims that all constituents of EcQs, except for the *wh*-word, are given. If this was the case, they would have been deaccented. The prosodic analyses of the *wh*-word showed two kinds of splits: first, there were differences between the EcEp and the other two conditions in terms of the f0-range and the duration of the *wh*-word. EcEp adds a flavour of surprise (cf. Lai 2009; Hu 2002). Second, there were differences between the InfQ and the two echo-question conditions in terms of the proportion of rising pitch accents on the *wh*-word (fewer rising accents in InfQ than the two EcQs). Since rising accents were realized in the majority of productions in all conditions, there does not seem to be a categorical contrast across conditions.

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4 Percentage of L* H-H% in non-fronted position: EcEp vs. InfQ β=1.23, SE=0.40, df=Inf, z=3.05, p<0.01; EcPer vs. InfQ β=1.28, SE=0.40, df=Inf, z=3.18, p<0.01; EcEp vs. EcPer: p>0.9; percentage of L*+H in fronted position: EcEp vs. InfQ β=2.07, SE=0.51, df=Inf, z=4.04, p<0.001; EcPer vs. InfQ β=1.77, SE=0.48, df=Inf, z=3.68, p<0.001; EcEp vs. EcPer: p>0.8.

Random forests are well suited to deal with gradient information (Liaw & Wiener 2002). The classification accuracy was above chance in both word orders, but it was not very high (66% and 46%, depending on the position of the *wh*-word). Therefore, the above-mentioned prosodic features do not predict the interpretation (EcEp/EcPer/InfQ) with a high accuracy. It is conceivable, of course, that the phonetic analyses missed some important features, so concluding that prosody does not provide reliable cues for discrimination is premature at this stage. This aspect is addressed in Experiment 2.

2.2 Experiment 2: Perception

A perception study with original recordings of Experiment 1 investigated how well human listeners can determine the interpretation from which a recording came. Unlike feature-based classifiers, human listeners have all cues at their disposal, not only the ones fed to the classifier. If other cues to prosody are relevant, we expect to see a higher accuracy for human listeners than for machine classifiers. In that case prosody would be a decisive factor in the interpretation of *wh*-inquisitive utterances.

2.2.1 Methods

Twenty-four native speakers of North American English (18 - 35 years, average = 23.9 years, SD = 4.3 years, 11 female, 10 male, 3 diverse) were recruited via Prolific. We chose nine items (three per condition per word order) from female speakers which represented typical realizations of the three conditions. As in Experiment 1, *condition* was manipulated within-subjects and *position* between-subjects. On each trial, participants saw the three possible contexts (displayed in a different order in each trial), heard the *wh*-question and had to select the most appropriate context.

2.2.2 Results

Table 1 shows the distribution of responses across conditions for the two word orders. Average accuracy was 61.1% for the *wh*-final condition and 60.2% for the *wh*-initial. There was a bias towards EcPer in the *wh*-final word order (50 out of 108 responses, 46.3%) and a bias towards InfQ in the *wh*-initial word order (65 out of 108 responses, 60.2%).

2.2.3 Discussion

Human classification accuracy outperformed machine classification in the *wh*-initial condition (60.2% vs. 44.2%) and was comparable in the *wh*-final condition (61.1%

	Wh-Final			*Wh*-Initial		
Perceived / Produced	EcEp	EcPer	InfQ	EcEp	EcPer	InfQ
EcEp	17	18	1	13	11	12
EcPer	3	23	10	1	17	18
InfQ	1	9	26	1	0	35
total	21	50	37	15	28	65

Table 1   Absolute numbers for participants' choice of contexts (i.e. what they perceived) in selected productions of Experiment 1.

vs. 67.0%, on average). This suggests that our phonetic analysis is missing a crucial feature for the *wh*-initial condition, such as relative intensity or voice quality, which was available for human listeners. Nevertheless, human classification was only at just over 60%. This suggests that prosody is not decisive for distinguishing the three conditions. Additionally, the bias towards EcPer in *wh*-final and towards InfQ in *wh*-initial indicates that speakers have a preferred word order for each reading (*wh*-non-fronted for EcPer, *wh*-non-fronted for InfQ), but this syntactic preference is also not strong enough for unambiguous discrimination (46.3% and 60.2%).

The empirical data show prosodic differences across the three conditions. EcPer patterned differently with respect to EcEp and InfQ depending on the cue. Overall, the prosodic differences do not seem strong enough to reliably distinguish between the three interpretations, neither for classifiers nor for human listeners.

3   Contextualizing alternatives

Given that word order does not determine the interpretation, and prosody is not a reliable cue either, the only other factor driving the interpretation of an utterance as an EcQ or an InfQ is its position in discourse.

In our analysis of EcQs, we follow current theories assuming that utterances are proposals to update the context (Stalnaker 1978) and adopt a system that allows us to refer back to such proposals. In this system sentential force indicates what component of context the utterance proposes to update: declaratives are proposals to update the (Stalnakerian) context set (Farkas & Bruce 2010), imperatives are proposals to update Common Preferences (Starr 2020) and interrogatives are proposals to update the QUD stack (Biezma & Rawlins 2017). Those proposals can be then *accepted* (which is the default), outright *rejected* or *resisted* (see Bledin & Rawlins 2016 for resistance moves).

Descriptively, looking at the contrast between (1) and (2), we can see that an InfQ obtains when we tacitly accept the preceding utterance. The subsequent inquisitive

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utterance presents a subsequent question within the larger topic (e.g., in (2) B accepts that A went to a restaurant and asks what they ate). For EcQs, on the other hand, the questioner has not accepted yet the previous proposal, either because they couldn't quite hear it or because they resist accepting what was said and require the speaker to repeat it (in (1), B either couldn't hear what it is that A ate or cannot believe that A ate ostrich and asks B to iterate what was said; e.g., to iterate their commitment). Importantly, in EcQs we always assume that something was said, unlike in InfQs:

(8)   A: I ate ostrich.

        B: What did you eat?

        A_1: # Since you want to know what I ate, I ate ostrich.

        A_2: Since you want to know what I said, I said that I ate ostrich.

EcQs are, hence, questions about what exactly the proposal to be evaluated is: they are questions at the proposal stage. This is the idea driving the analysis spelled out in §3.1. In §3.1.2 we propose a unified semantics of EcQs and InfQs in which the interpretation pays attention to the utterance's position in discourse.[5]

In the general theoretical picture, EcQs allow us to argue that we need systems representing the proposal stage of utterances. We capitalize on this richer articulation of context to be able to investigate different effects of utterances that go beyond plain acceptance.

3.1 A unified semantics for EcQs and InfQs

In the sketch above we claimed that EcQs are inquiries evoking alternatives relevant at the proposal stage. There are several systems on the market that would allow us to cash out our proposal. In Farkas & Bruce's 2010 system, for example, EcQs would relate evoked alternatives to the alternative the speaker placed on the *table*. For ease of notation, we adopt the system in Biezma & Rawlins 2017; Biezma 2020, §3.1.1. In §3.1.2 we show how relating alternatives evoked by utterances to the previous move allows us to keep the same semantics for EcQs and InfQs across clause-types. We will focus on EcQs preceded by an assertion. The model can be extended to deal with second order questions but we don't include this discussion for space reasons.

3.1.1 A dynamic model featuring proposals

In Biezma & Rawlins 2017, a context c contains a context set cs (a set of worlds at the intersection of the propositions in the common ground), updated by declaratives,

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5 For Ginzburg & Sag (2001), EcQs are a type of *reprise questions* and discourse also plays an important role. In their system the meaning of an echo question refers to the illocutionary force of the utterance that it reprises/is anaphoric to, unlike InfQs.

and a partially ordered set of questions QUD (or QUD-stack; see Roberts 1996), updated by interrogatives.[6] These two together form the local context of c, l_c. The context also contains a slot to record proposals, $\mathscr{F}$. If there is no proposal awaiting evaluation (e.g., in a discourse initial situation), $\mathscr{F} = \emptyset$, and if there is a proposal awaiting, $\mathscr{F}$ is a copy of the local context l_c with the modification proposed.

(9) A *context c* is a tuple $\langle cs, \text{QUD}, \mathscr{F} \rangle$ s.t.:

    a. $l_c = \langle cs_c, \text{QUD}_c \rangle$ is a local context.

    b. $\mathscr{F}_c$ is either a local context or $\emptyset$. Call $\mathscr{F}_c$ the *projected context*.

For convenience, in what follows we simplify formal details in Biezma & Rawlins 2017; Biezma 2020. We write $\mathscr{F}_{l_c, X}$ to refer to a projected context of a context with local context l_c recording an update X. Assertions (proposals to update cs) are answers to (implicit) questions and hence, for the assertion to be felicitous, it has to be relevant to the immediate question under discussion, IQUD (the top question on the QUD stack, $top(\text{QUD})$), i.e. to provide a (partial) answer to the question. This question, if not explicit, is identified via the focus structure of the utterance (à la Rooth) and accommodated before the update process starts. In the case of the declarative *I ate ostrich*, we can make the default assumption that *ostrich* is marked as focused ([I ate [ostrich]$_F$]), and hence the IQUD would be similar to the question *what did you eat?* In (11) we define updates by declaratives, exemplified in (12). We assume an initial context $c = \langle cs, \text{QUD}, \emptyset \rangle$, and provide the auxiliary definition of *content proposition* (CProp) to be able to characterize assertions in Hamblin semantics, where declaratives denote singleton sets containing a proposition.[7]

(10) Let $[\![\phi]\!]$ be a singleton set containing the proposition p. We call p the content proposition of $[\![\phi]\!]$ and write $\text{CProp}([\![\phi]\!])$

(11) $c_1 = c + \ulcorner \text{Assert}(\phi) \urcorner = \langle cs_c, \text{QUD}_c, \mathscr{F}_{l_c, \ulcorner \text{Assert}(\phi) \urcorner} \rangle$ s.t. **Assertion**

    a. $\mathscr{F}_{c_1} = \mathscr{F}_{l_c, \ulcorner \text{Assert}(\phi) \urcorner} = \langle cs_c \cap \text{CProp}([\![\phi]\!]), \text{QUD}_c \rangle = l_c \oplus \text{CProp}([\![\phi]\!])$ $\oplus$

    b. Felicitous only if (i) $\mathscr{F}_c = \emptyset$; (ii) $cs_c \cap [\![\phi]\!]^c \neq \emptyset$ and
                  (iii) $[\![\phi]\!]^c$ is relevant to IQUD_c

(12) $c_1 = c + \ulcorner \text{Assert(I ate ostrich)} \urcorner = \langle cs_c, \text{QUD}_c, \mathscr{F}_{l_c, \ulcorner \text{Assert(I ate ostrich)} \urcorner} \rangle$

    a. $\mathscr{F}_{c_1} = \langle cs_c \cap \text{CProp}([\![\text{I ate ostrich}]\!]^c), Q_c \rangle = l_c \oplus \text{CProp}([\![\text{I ate ostrich}]\!]^c)$

    b. Felicitous only if (i) $\mathscr{F}_c = \emptyset$; (ii) $cs_c \cap \text{CProp}([\![\text{I ate ostrich}]\!]^c) \neq \emptyset$ and
                  (iii) $\text{CProp}([\![\text{I ate ostrich}]\!])$ is relevant to IQUD_c.

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6 We leave aside updates triggered by sentences with imperatives. They would update a different element in the context, a set of common preferences. Discussion regarding this update as well as EcQs preceded by an interrogative are not included for space reasons.

7 In Biezma & Rawlins 2017; Biezma 2020 the operations on local contexts $\oplus/\oslash$ are defined over syntactic objects. Here we take a shortcut and take them to range over semantic objects.

The utterance of the declarative doesn't update cs_c per se, but proposes to update it: the utterance only affects $\mathscr{F}_c$, not cs_c. Once the proposal has been made, it is evaluated by the addressee. If accepted, $\mathscr{F}_{c_1}$ becomes the current local context and the projected context slot is emptied. This is defined in (13) and exemplified in (14) for the running example:

(13) $c + \ulcorner \text{Accept}_x \urcorner = \langle cs_{\mathscr{F}_c}, Q_{\mathscr{F}_c}, \emptyset \rangle$ **Acceptance**

(14) $c_2 = c_1 + \ulcorner \text{Accept}_x \urcorner = \langle cs_c \cap \text{CProp}(\llbracket \text{I ate ostrich} \rrbracket^c), \text{QUD}_c, \emptyset \rangle$

The assertion is taken to provide an (partial) answer to the IQUD and, if it is resolved, at the end of the update the IQUD is discarded. This maintenance operation is represented in (15) by making use of the $pop(K)$ operation on stacks, which discards the top-most element of the stack K. In (16) it is added to our running example:

(15) $c + \ulcorner \text{pop} \urcorner = \langle cs_c, pop(\text{QUD}_c), \mathscr{F}_c \rangle$ **IQUD resolution**

(16) $c_2 + \ulcorner \text{pop} \urcorner = \langle cs_{c_2}, pop(\text{QUD}_{c_2}), \emptyset \rangle = \langle cs_{c_2}, pop(\text{QUD}_c), \emptyset \rangle$

Similarly, we can represent the update of the QUD stack via the utterance of an interrogative, which makes use of the usual $push(K, s)$ operation on stacks that places a new element, s, on the the top of the given stack, K. Questions are relevant (and, hence, felicitous) if the QUD stack is empty (QUD $= \langle \rangle$), as in discourse initial situations, or if they are subquestions to the current IQUD, where an answer to the subquestion is (at least) a partial answer to the IQUD (i.e. it is entailed by the IQUD/ $top(\text{QUD})$). Updates by interrogatives are exemplified in (18).

(17) $c + \ulcorner \text{Question}(\phi) \urcorner = \langle cs_c, \text{QUD}_c, \mathscr{F}_{l_c, \ulcorner \text{Ques}(\phi) \urcorner} \rangle$ s.t.   **Question**

a. $\mathscr{F}_{l_c, \ulcorner \text{Ques}(\phi) \urcorner} = \langle cs_c, push(\text{QUD}_c, \llbracket \phi \rrbracket) \rangle = l_c \oslash \llbracket \phi \rrbracket$ $\oslash$

b. Felicitous only if (i) $\mathscr{F}_c = \emptyset$ and (ii) $\text{QUD}_c = \langle \rangle$ or $\llbracket \phi \rrbracket$ is entailed by $top(Q_c)$.

(18)   Where $[_Q \text{You ate what}]$ is the syntactic representation of *what did you eat?*
$c + \ulcorner \text{Question}([_Q \text{You ate what}]) \urcorner = \langle cs_c, \text{QUD}_c, \mathscr{F}_{l_c, \ulcorner \text{Ques}([_Q \text{You ate what}]) \urcorner} \rangle$ s.t.

a. $\mathscr{F}_{l_c, \ulcorner \text{Ques}(\phi) \urcorner} = \langle cs_c, push(\text{QUD}_c, \llbracket [_Q \text{You ate what}] \rrbracket) \rangle = l_c \oslash \llbracket [_Q \text{You ate what}] \rrbracket$

b. Felicitous only if (i) $\mathscr{F}_c = \emptyset$ and (ii) $\text{QUD}_c = \langle \rangle$ or $\llbracket [_Q \text{You ate what}] \rrbracket$ is entailed by $top(\text{QUD}_c)$.

With these definitions in hand, let us turn now to the semantics of EcQs.

3.1.2   A unified semantics for EcQs and InfQs

In order to provide a unified semantics for EcQs and InfQs, let us start by considering the semantics of InfQs. For space reasons, we will limit the discussion to WhInts

and WhDecs. We adopt Biezma's 2020 Hamblin semantics for WhInts and WhDecs, which builds on Kratzer & Shimoyama 2002 and Biezma & Rawlins 2012. Let us start by the semantics of *wh*-interrogatives, WhInts, and proceed then with WhDecs.

In Hamblin semantics the meaning of an interrogative is the set of its possible answers. The semantic alternatives introduced by the *wh*-word are collected by the Q operator. This operator, originally proposed to deal with InfQs, leaves the alternatives intact, but requires that semantic alternatives be also in the IQUD, and that the question not be trivial (that there is more than one possible alternative).[8] In declaratives, alternatives are collected by '$\exists$', which will become relevant below in our discussion of WhDecs. This operator flattens out the set of alternatives and requires that one of the salient alternatives in the IQUD be true. Crucially, the semantic alternatives shape the IQUD. (Our proposal will modify these operators to add a link between the alternatives and $\mathscr{F}$.) Alternatives introduced by the *wh*-word compose with the rest of the clause via pointwise function-argument application.

(19) $\llbracket wh\text{-}\rrbracket^c = \{x : x \in D_\tau \ \& \ x \text{ is contextually salient}\}$ (where τ stands for the type of the given *wh*-word)

(20) Where $\llbracket \alpha \rrbracket \subseteq D_{\langle\langle s,t\rangle,t\rangle}$ (i.e., $\llbracket \alpha \rrbracket$ is a set of propositions)
   a. $\llbracket \exists \alpha \rrbracket^c = \{\lambda w. \exists p \in \llbracket \alpha \rrbracket^c : p(w) = 1\}$, defined only if $\llbracket \alpha \rrbracket^c \subseteq \text{IQUD}_c$
   b. $\llbracket Q\alpha \rrbracket^c = \llbracket \alpha \rrbracket^c$ defined only if $\llbracket \alpha \rrbracket^c \subseteq \text{IQUD}_c$ and $|\llbracket \alpha \rrbracket^c \cup \text{IQUD}_c| > 1$

(21) $\llbracket \text{what did you eat?} \rrbracket^c = \llbracket [_Q \text{ you ate what}] \rrbracket^c = \llbracket Q \rrbracket^c (\llbracket \text{you ate what} \rrbracket^c) = \llbracket Q \rrbracket^c (P)$

   $P = \{p : p = \lambda w. \text{ the addressee ate x in } w, \text{ for x context. sal. in } c\}$

   $\llbracket Q \rrbracket^c (P) = P$, defined only if $P \subseteq \text{IQUD}_c$ and $|P \cup \text{IQUD}_c| > 1$

WhDecs like *you ate what?* are analyzed as declaratives (in Hamblin semantics these are singleton sets of propositions). As in other declaratives, the semantic alternatives introduced by the *wh*-word in WhDecs are collected by '$\exists$' instead of 'Q' (see, e.g., the case of declaratives with disjunction in Hamblin semantics):

(22) $\llbracket \text{you ate what?} \rrbracket^c = \llbracket \exists [\text{you ate what}] \rrbracket^c = \llbracket [\exists [\alpha]] \rrbracket^c$

   $\llbracket [\alpha] \rrbracket^c = \{p : p = \lambda w. \text{ you ate x, for } x \text{ a contextually salient edible thing in } c\}$

   $\llbracket [\exists [\alpha]] \rrbracket^c = \{\lambda w. \exists p \in \text{IQUD}_c : p(w) = 1\}$, defined only if $\llbracket \alpha \rrbracket^c \subseteq \text{IQUD}_c$.

As a declarative, the WhDec is trivial, it merely states that one of the alternatives in the IQUD is true. The WhDec serves the purpose of signaling what is the question

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8 This definition allows for the IQUD to contain also the null alternative (e.g., that the addressee didn't eat anything) if the context allows it. The null alternative is not one of the semantic alternatives in the question but rather the alternative stating that none of the semantic alternatives is true. See Biezma 2020 for discussion.

that participants are already committed to answer next in discourse: unlike WhInts, WhDecs do not propose to pursue a new communal inquiry but presuppose that participants already committed to pursuing a question that is awaiting to be resolved. This question, the IQUD, is identified via focus structure (à la Rooth). In (22), for example, it is a question similar to *what did you eat?* (i.e., its WhInt-counterpart).[9] The difference between WhInts and WhDecs derives their different behavior in discourse (the reader is referred to Biezma 2020 for details).

The interpretation of WhInts and WhDecs above makes the default assumption that the projected context is empty (nothing awaits evaluation). However, when we investigated EcQs above, we saw that they are inquiries addressed before accepting the preceding move: we obtain an EcQ when $\mathscr{F} \neq \emptyset$ and the semantic alternatives in the utterance are alternatives to the proposal awaiting evaluation. To see how the dynamic update proceeds and differs in each case, let us contrast the update process leading to an InfQ, (23), with the update process leading to an EcQ, (24).

(23) $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad c_0 = \langle cs, \mathrm{QUD}, \emptyset \rangle$

    A: I went to a restaurant yesterday.

      $c_1 = c_0 + \ulcorner\mathrm{Assert(I\ went\ to\ a\ restaurant\ yesterday)}\urcorner = \langle cs_{c_0}, \mathrm{QUD}_{c_0}, \mathscr{F} \rangle$

        $\mathscr{F}_{c_1} = l_{c_0} \oplus \mathrm{CProp}(\llbracket \mathrm{I\ went\ to\ a\ restaurant\ yesterday} \rrbracket^{c_0}) =$

          $\langle cs_{c_0} \cap \mathrm{CProp}(\llbracket \mathrm{I\ went\ to\ a\ restaurant\ yesterday} \rrbracket^{c_0}), \mathrm{QUD}_{c_0} \rangle$ **Assert**

      $c_2 = c_1 + \mathrm{Accept_B} = \langle cs_{\mathscr{F}_{c_1}}, \mathrm{QUD}_{\mathscr{F}_{c_1}}, \emptyset \rangle$ **Accept**

      $c_3 = c_2 + \ulcorner\mathrm{Pop}\urcorner = \langle cs_{\mathscr{F}_{c_1}}, pop(\mathrm{QUD}_{\mathscr{F}_{c_1}}), \emptyset \rangle$ **IQUD resolution**

    B: What did you eat?

      $c_4 = c_3 + \ulcorner\mathrm{Question}([_Q\mathrm{you\ ate\ what}])\urcorner = \langle cs_{c_3}, \mathrm{QUD}_{c_3}, \mathscr{F} \rangle$

        $\mathscr{F}_{c_4} = l_{c_3} \oslash \llbracket [_Q\mathrm{You\ ate\ what}] \rrbracket^{c_3} =$

          $\langle cs_{c_3}, push(\mathrm{QUD}_{c_3}, \llbracket [_Q\mathrm{you\ ate\ what}] \rrbracket^{c_3}) \rangle$ **Question**

In (23) we assume that A's assertion is accepted and B proceeds with further questioning. It is an InfQ. However, in the case of EcQs, (24), the inquiry is made before the proposal that A had made previously is accepted (in fact, the goal is to understand what needs to be accepted).

(24) $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad c_0 = \langle cs, \mathrm{QUD}, \emptyset \rangle$

    A: I ate ostrich.

      $c_1 = c_0 + \ulcorner\mathrm{Assert(I\ ate\ ostrich)}\urcorner = \langle cs_{c_0}, \mathrm{QUD}_{c_0}, \mathscr{F} \rangle$

        $\mathscr{F}_{c_1} = l_{c_0} \oplus \mathrm{CProp}(\llbracket \mathrm{I\ ate\ ostrich} \rrbracket^{c_0}) =$

          $\langle cs_{c_0} \cap \mathrm{CProp}(\llbracket \mathrm{I\ ate\ ostrich} \rrbracket^{c_0}), \mathrm{QUD}_{c_0} \rangle$ **Assert**

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9 In Biezma's (2020) system, the IQUD may also include the null answer, which is not a semantic alternative but the alternative stating that none of the live focus alternatives is true. See ftn. 8.

$$c_2 = c_1 + \text{Accept}_B = \langle cs_{\mathscr{F}_{c_1}}, \text{QUD}_{\overline{\mathscr{F}_{c_1}}}, \emptyset\rangle \qquad \textbf{Accept}$$

$$\cancel{c_3 = c_2 + \ulcorner\text{Pop}\urcorner = \langle cs_{\mathscr{F}_{c_1}}, pop(\text{QUD}_{\overline{\mathscr{F}_{c_1}}}), \emptyset\rangle} \qquad \textbf{IQUD resolution}$$

B_1: What did you eat? **WhInt**

B_2: You ate what? **WhDec**

The main idea driving our interpretation of EcQs is that the relevant alternatives are alternatives to what has been proposed (and is recorded in $\mathscr{F}$). In pondering the semantic alternatives we take into consideration how they relate to the relevant alternatives in discourse. This can be achieved by encoding in the semantics a link between the evoked alternatives and $\mathscr{F}$ as follows:

(25) $[\![\text{you ate what}]\!]^c = \{p : p = \lambda w.\ \text{the addressee ate } x \text{ in } w, x \text{ context. sal. in } c\}$

(26) $[\![(24\text{B}_1)]\!]^{c_1} = [\![_Q \text{ you ate what}]\!]^{c_1} = [\![Q]\!]^{c_1}([\![\text{you ate what}]\!]^{c_1}) = [\![Q]\!]^{c_1}(P) =$
$\{p : p = q\ \&\ \mathscr{F}_{c_1} = l_c \oplus q \text{ for } q \in [\![\text{you ate what}]\!]^{c_1}\} = P'$

$[\![Q]\!]^{c_1}(P) = P'$ defined only if $P' \subseteq \text{IQUD}$ or $\text{IQUD} = \emptyset$ and $|P \cup \text{IQUD}| > 1$

(27) $[\![(24\text{B}_2)]\!]^{c_1} = [\![_\exists \text{ you ate what}]\!]^{c_1} = [\![\exists]\!]^{c_1}([\![\text{you ate what}]\!]^{c_1}) =$
$\{\lambda w.\exists p \in \text{IQUD} : p(w) = 1\}, \text{ defined only if}$
$\{p : p = q\ \&\ \mathscr{F}_{c_1} = l_c \oplus q \text{ for } q \in [\![\text{you ate what}]\!]^{c_1}\} \subseteq \text{IQUD}$

In accepting the WhInt-EcQ, participants agree to address the question regarding what was said that A ate, and accepting the WhDec-EcQ involves accepting that participants already committed to addressing the question regarding what A said that they ate. The difference between the EcQs in (26)/ (27) and the InfQs (21)/(22) is the relation established between the semantic alternatives in the utterance and what is proposed to update the context. We can obtain an InfQ or an EcQ maintaining the same semantics by linking the alternatives evoked to $\mathscr{F}$ as in (28). (We limit our discussion here to utterances with a preceding assertion for space reasons.)

(28) Let $[\![\alpha]\!] \subseteq D_{\langle\langle s,t\rangle,t\rangle}$,
    a. $[\![_Q\alpha]\!]^c = \{p : p = (q\ \&\ \mathscr{F}_c = l_c \oplus q), \text{ for } q \in [\![\alpha]\!]^c\} = P'$,
        defined only if $P' \subseteq \text{IQUD}$ or $\text{IQUD} = \emptyset$ and $|P' \cup \text{IQUD}| > 1$.
    b. $[\![_\exists\alpha]\!]^c = \{\lambda w.\exists p \in \text{IQUD} \text{ s.t. } p(w) = 1\}$,
        defined only if $\{p : p = (q\ \&\ \mathscr{F}_c = l_c \oplus q), \text{ for } q \in [\![\alpha]\!]^c\} \subseteq \text{IQUD}$

In the semantics above, when there is no proposal awaiting evaluation, i.e., $\mathscr{F}_c = \emptyset$, the second conjunct is vacuously true and we obtain the semantics for WhInts and WhDecs in InfQs. In that case, the definedness conditions are easily obtained, since the question is easily understood as being part of an ongoing overall topic. In contrast, when there is a proposal awaiting evaluation, the semantic alternatives are

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related to the type of alternatives in the proposed update recorded in $\mathscr{F}_c$, making the inquiry one about what was proposed.[10]

Notice that the IQUD in the definedness condition in (28) cannot be the current IQUD_c (e.g., in EcQs like (26) and (27) the IQUD cannot be similar to *what did you eat?*, the question identified by the default focus structure of A's utterance *I ate* $[ostrich]_F$). It also can't be merely accommodated in the current stack, since it is not entailed by other questions in the stack and would be ill-formed. An EcQ assumes a new QUD altogether. Intuitively, the utterance opens a new line of inquiry that needs to be resolved before returning to the original discourse. This new issue is a meta-discursive one. We leave for future investigation the mechanisms allowing for "independent" inquiries required to solve a meta-discursive issue.

3.2 Taking stock

The proposal made above argues that in interpreting utterances we do not only take into consideration what are live alternatives in a traditional context set, but also how they relate to salient alternatives in the proposed update (encoded in $\mathscr{F}$). The proposal is that the semantics of utterances encode this relation with the context which is, in this way, underspecified. Whether an InfQ or an EcQ obtains depends then on the context in which the utterance is embedded. We can have the same semantics for InfQs and EcQs while keeping the interpretation true to form.

4 Predictions

EcQ's relation with the preceding utterance: One of the questions in the literature on EcQs concerns why EcQs have to immediately follow the utterance they echo. In the proposal we champion, EcQs are merely the interpretation of inquisitive utterances whose semantic alternatives relate to a proposal that has just been made. Hence, EcQs are inherently related and have to follow the utterance they echo.

EcQs are not just about linguistic expressions: EcQs have been proposed to be questions about expressions or even some kind of quotatives (see Janda 1985; Blakemore 1994; Huddleston 1994; Iwata 2003; Sudo 2007). In the proposal above, EcQs are not required to be about expressions (the semantics proposed refers to propositional content and not to how it's phrased). This makes the right prediction for examples like (29), in which we interpret B's utterance as an EcQ even though the phrasing doesn't align verbatim with the preceding utterance:

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10 While we don't have enough space here to address updates by interrogatives or imperatives, the system can be easily extended to those cases. In the case of *wh*-interrogatives (see, e.g.,(5), *who ate ostrich?*), for example, $\mathscr{F} = l_c \oslash [\![\text{who ate ostrich?}]\!]$, a set of propositions, and the EcQ (*who ate what?*) is a family of questions each of which is an alternative to the update proposed.

(29) A: Morgan called Taylor a Republican.

  B: Morgan insulted who?

At any rate, there are EcQs that are clearly below the word level (Janda 1985; Ginzburg & Sag 2001; Artstein 2002; Sobin 2010; Sudo 2007):

(30) A: Try our new chajitas!

  B: Cha-WHAT-as?   (Janda 1985: 175)

Given a system that derives the right alternatives for utterances like (30B) the EcQ interpretation for such utterances could be derived just in the same way as in other EcQs: the system only requires the identification of the right alternatives between the semantic alternatives in the EcQ and the discourse update proposed.

The existential presupposition: EcQs do not trigger an existential presupposition any more than WhDec- or WhInt-InfQs do and, as in those cases, it can be cancelled:

(31) A: Don't be angry today, I ate something! I ate #%*#%.

  B: You ate what? Never mind, Morgan told me that you didn't eat anything again. Stop lying to me.

While B can utter the EcQ without assuming that any of the semantic alternatives is true, what can't be denied in EcQs is that there was a previous utterance proposing to update the context with alternative(s) comparable to the semantic alternatives in the EcQ. Recall that this is the only way to obtain an EcQ: EcQs are the reading obtained when there is a proposal awaiting evaluation.

WhDecs as stereotypical EcQs: While all strategies available to inquire about non-discursive facts are available to issue an EcQ, it is true that the stereotypical *wh*-EcQ is a WhDec (see also discussion in §2.2.3 regarding word-order bias). Considering the differences between WhInts and WhDecs this is expected: the WhInt proposes to address the question of what was said (which needs to be evaluated), while the WhDec establishes that participants have already agreed on what question has to be addressed next: instead of proposing an inquiry, they impose it. Given that EcQs are meta-discursive inquiries that interrupt the original discourse to request a clarification before proceeding (the main discursive goal is the one in the original discourse), WhDecs are very well suited to "enforce" addressing the meta-discursive inquiry. WhInts are of course possible too, but WhDecs provide a shortcut that is very well suited for these circumstances making them the favored option.

Our proposal maintains the interpretation of EcQs true to form and, hence, the properties of inquiries about non-discursive facts are preserved in inquiries regarding discursive facts, naturally deriving the contrasts described above.

Predictions for other languages: Our proposal addresses how to obtain an EcQ or an InfQ interpretation from string identical utterances by taking into consideration

where in discourse the utterance is placed, since there is no other reliable linguistic cue in English. Word order is not a cue to trigger EcQs in English and, as we showed, nor is prosody. That prosody is not a cue to distinguish between EcQs and InfQs seems to be also the case in German (see preliminary results in Repp & Rosin 2015). This is not to say that EcQs cannot be triggered by means of prosodic cues in other languages and our proposal leaves room for crosslinguistic variation. If there were languages with conventional cues to convey EcQs, these could be interpreted as conveying that $\mathscr{F} \neq \emptyset$ and, hence, enforcing the relation between the semantic alternatives in the utterance and the relevant alternatives in the context update.

There are of course other means to inquire about what has been said and, e.g., quotatives are a means to do that (see e.g. Noh 1995 for Korean *-ko* and Sudo 2007 for Japanese *-tte*). This is exemplified with the Japanese quotative *-tte*:

(32) Tarou-ga   "hai" tte kotaeta.   (33) John-ga   nani-o   katta   tte?
      Tarou-Nom yes   tte said   John-nom what-acc bought tte

      'Tarou said "yes"'   ≈ 'John said he bought a what?'

Our proposal doesn't say anything about the semantics of quotatives.

5 Conclusion

We tested whether the prosodic realization differs for EcEp, EcPer and InfQ and whether it is a reliable cue to distinguish between the three interpretations. A production experiment showed prosodic differences in terms of overall f0-contour, phonetic cues (f0-range and duration of the *wh*-word), pitch accent realization and boundary tones. However, neither an automatic classifier based on random forests nor human listeners were very accurate in correctly interpreting the prosodic cues leading to the conclusion that prosody is not a reliable cue to predict the utterance's interpretation as EcEp/EcPer/InfQ.

For space reasons we have not addressed here how to extend our model to EcQs responding to interrogatives, nor claimed differences between InfQs and EcQs concerning island-effects and superiority effect violations either (but see Ginzburg & Sag 2001 for discussion regarding the accuracy of the empirical claims).

Our proposal argues that in characterizing semantic alternatives we ought to consider how they relate to the ongoing discourse. Alternative semantics has taught us that semantic alternatives can be contextually restricted by what is live and salient in the context of utterance. The semantics proposed here argues that alternatives are also restricted by what is relevant in relation to the previous discourse move. The $\mathscr{F}$-slot plays a crucial role by keeping track of what awaits evaluation. This further supports that we need articulated models that represent proposals to be able to deal with phenomena involving more than mere acceptance.

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