

Toward a bestiary of English intonational contours*

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1. Introduction

Utterance final intonation rises in English have garnered attention in both the phonetics and semantics/pragmatics literature. At least four distinct rising tunes have been identified: the contradiction contour (CC; Liberman & Sag 1974, Ladd 1980), rise-fall-rise (RFR; Ward & Hirschberg 1985, Wagner 2012, Constant 2012), the incredulity contour (Hirschberg & Ward 1992), and the rise typically involved in yes/no questions (YNrise; Pierrehumbert & Hirschberg 1990, Bartels 1999, Truckenbrodt 2011).¹ Whether these tunes are actually semantically/pragmatically or phonetically/phonologically distinct from one another has been questioned (Liberman & Sag 1974, Hirschberg & Ward 1992, Westera 2013). Almost all prior studies are based on utterances produced by the researchers, which are then subjected to judgments, sometimes experimentally. This may introduce biases due to researchers' particular hypotheses, limiting the generalizability of the results. Even if a particular contour is indeed compatible with a certain context, there has been no attempt to test whether speakers actually produce the respective contours in contexts conducive to their use with any frequency, and which alternative contours might suit the same need.

This paper reports on a production study and a perception study that take first steps to address some of these issues: (i) How frequently do speakers actually produce these tunes in the contexts said to license them? (ii) Which other tunes can be used in those contexts? (iii) Are the tunes acceptable in other contexts? Another issue we aim to address is that the intonation literature has not usually made recordings of key examples available to readers, perhaps due to lack of means (this is starting to change, cf. Wells 2006, Constant 2012, Goodhue & Wagner 2015). Sometimes it is unclear which intonation an author has in mind, or whether two authors are talking about the same tune or not. A related methodological problem is that we don't know how many tunes or variations of tunes there are, so we cannot be sure at which level of granularity to report a particular tune so that future researchers have all the information they need to appreciate the results. We aimed to avoid

*Thanks to members of prosody.lab.

¹A fifth rising tune, fall-rise, is not discussed here.

these issues by getting consent to release our results online as a corpus. The data can be browsed at <http://prosodylab.org/research/bestiary/>, and will be made available to other researchers upon request.

In this paper, we introduce a characterization of certain intonational tunes, and their meanings (section 2). We then present results of a production study that elicited utterances in certain types of contexts and with a particular intention that prior research suggests should be conducive to use of a certain tune. We annotated the results based on our taxonomy of tunes (section 3), in order to address questions (i) and (ii). We then tested whether our classification leads to meaningful results by subjecting all utterances to perceptual evaluation in different contexts (section 4), in order to address question (iii).

Our analysis of our corpus remains preliminary and limited. Apart from potential annotation errors, it is likely that there are more systematic shortcomings: We may have grouped utterances together that carry similar but meaningfully different tunes because our taxonomy is not fine-grained enough; we already know that there are various tunes in our corpus that are waiting to be properly labeled and analyzed in more detail, which, for the time-being, are classified in a catch-all ‘other’ category; and finally, it is very possible that our taxonomy might turn out to be fundamentally wrong and even misguided, because we, and other researchers whose work we base our taxonomy on, simply cut the pie in the wrong way. The analysis of the data, in other words, is a work in progress, and necessarily so, given the current incomplete understanding of intonational phonology and meaning. By making the data publicly available, we hope the analysis of it and other data on intonation will become an on-going process, out of which a more complete bestiary of English intonational tunes will eventually emerge.

2. Characterizations of the relevant contours

Our object of study is the conventional linguistic meaning of intonation (Gussenhoven 2004). Following previous research (cf. Bartels 1999, Constant 2012, Goodhue & Wagner 2015, Truckenbrodt 2011, Wagner 2012, Ward & Hirschberg 1985), we assume that intonational meanings operate over propositions or sets of alternative propositions. The idea is that an intonational tune (or sometimes just a boundary tone) composes with a linguistic object that denotes a proposition, and contributes additional meaning. Some researchers have argued that such intonational meanings are composed out of the meanings of smaller intonational morphemes (Bartels 1999, Pierrehumbert & Hirschberg 1990, Truckenbrodt 2011, Westera 2013). We start with a different assumption, that entire intonational contours are morphemes in the lexicon with corresponding meanings. These morphemes are built from smaller phonological units just as words are built from phonemes, but we assume that these smaller phonological units are not themselves meaningful. Therefore, our working hypothesis of intonational meaning is non-compositional in that the meanings of contours are not hypothesized to result from the composition of smaller meaningful pieces.²

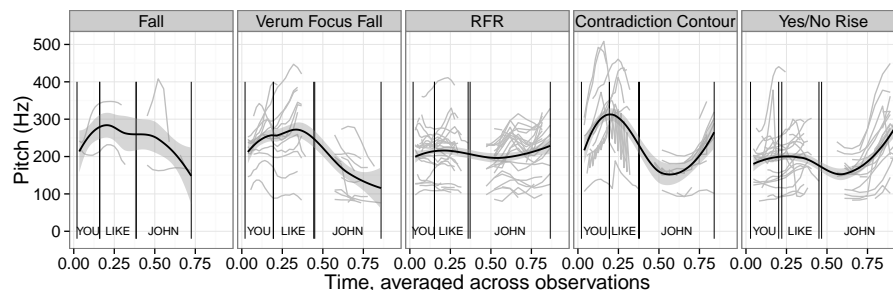
²Of course, it is possible that some aspects of English intonational meaning are compositional *and* that holistic tune-meaning pairs exist in the lexicon (cf. Bartels 1999, p. 4).

Toward a bestiary of English intonational contours

One reason for this is practical: We found that training annotators to listen for sentence-level tunes is easy, and leads to fairly consistent results across annotators. Another is methodological: We worry that by looking at highly decomposed aspects of a contour (e.g., a final rise), we might lose rather than gain information. Consider figure (1) below, in which there are several English contours that rise utterance finally. Our experimental results demonstrate that the contexts of use for each of these contours are largely distinct. When listening to these tunes holistically, it is clear that they're different, but when only listening to the final rise in isolation, it is much less clear, and one might be tempted to annotate two or more of them as identical. And yet the plots point to some subtle and some not so subtle differences in the final rises. An annotation of the phonological pattern at a level beyond what can be meaningfully decomposed might be difficult without a good understanding of the overall system, which we currently lack. We can't be certain how to decompose these tunes into meaningful units going in.

The physical forms of the contours of interest are demonstrated by the average of all observations of each contour for a single item in figure (1). We will provide a ToBI transcription for each one below. However as discussed above, even using ToBI and pitch tracks it is not always clear what particular intonation researchers have in mind. Readers are encouraged to follow the link in section 1 and listen to various examples of the contours themselves to get a clear idea of what we have in mind for each contour category.

(1) *Average contours in black, individual observations in grey.*



Following Truckenbrodt (2011), Wagner (2012), Constant (2012) and others, we assume that intonational meaning does not form part of the asserted content.³ We treat the semantics of intonations as partial identity functions. They take propositions as inputs, check that certain felicity conditions are met, and then return the propositions as outputs.

Falling intonation (fall) has been characterized in ToBI as H* L-L% (Pierrehumbert & Hirschberg 1990, Truckenbrodt 2011). Pitch accents (indicated by α^*) align with main sentence stress. In our example *you like John*, stress falls on *John*, so the fall happens utterance finally. Truckenbrodt (2011) has characterized the meaning contribution of H* as presupposing that a salient proposition is being added to the common ground. Bartels (1999) attributes roughly the same meaning to L- rather than H*. We agree with this characterization of the meaning of falls, even though we keep open the possibility that the meaning could be due to the entire contour rather than to the particular pitch or phrase accents themselves.

³We do not take a stand on whether intonations contribute presuppositions or conventional implicatures.

The next category, *verum focus fall* (VF fall), is a subtype of the declarative fall just discussed. However, they have a non-canonical prominence pattern in that the H* pitch accent aligns with the verb rather than with the object (e.g. *you LIKE John*). We analyze this as VERUM focus (Höhle 1992), which we claim is focusing of the polarity head. If nothing else is focus-marked, a focussed polarity head usually manifests as prosodic prominence on the auxiliary or verb (cf. Geurts & Van der Sandt 2004, Goodhue 2016, Samko 2016). Assuming Rooth 1992, marking the polarity head as focussed requires the rest of the sentence to be contextually given since the antecedent for this focus marking can only differ in its F-marked parts (cf. Wagner & Klassen 2015). Therefore, the VF fall restricts the context by requiring the proposition involved to be discourse salient (cf. Richter 1993, Romero & Han 2004, Gutzmann & Castroviejo Miró 2011, Goodhue 2016).

Rising intonation typically found in polar questions (YNrise), has been characterized as L* H-H% (Pierrehumbert & Hirschberg 1990, Bartels 1999, Truckenbrodt 2011). Note that in our production experiment, speakers frequently produced utterances with double prominence, once on the subject *you* and again on the object *John*. The result is that the utterance wide contour rises on the subject before falling again and rising utterance finally. The contour is still distinguishable as a YNrise, largely because the final rise is higher than the initial rise (see figure (1)). Truckenbrodt (2011) characterizes H- as presupposing that a salient proposition is being questioned. Again, we adopt Truckenbrodt's proposal, allowing that the meaning may be due to the entire rising contour, not an individual tone.

The transparently named rise-fall-rise (RFR) rises on a focussed constituent (at the main sentence stress), then falls again before rising utterance finally (characterized by Ward & Hirschberg (1985) as L*+H L-H%). In (1), focus is on *John*, therefore the rise, fall and rise are all located on this monosyllable. Note that RFR's characteristic form is not visible in the average contour, but can be seen in the individual productions. As for its meaning, we propose that RFR takes a proposition *p* as input, and returns *p* as output while insinuating alternatives to *p*. There are two more precise antecedents to this characterization in the literature. Wagner (2012) argues that RFR indicates that at least one alternative to *p* is possibly true (or could be asserted), while Constant (2012) argues that RFR indicates that the speaker cannot safely claim any of the alternatives to *p*. In the case of our example sentence *you like John* with focus on *John*, alternatives would be e.g. *you like Mary*, *you like Bill*, etc. (cf. Rooth 1992). Both accounts require there to be alternatives to *p*, and both accounts posit that the contour serves to draw attention to the fact that the speaker does not actually assert the alternatives, which leads the hearer to draw inferences as to the reason why the speaker did not assert them. E.g. the speaker is not in an epistemic position to assert them, or the speaker thought asserting *p* was more polite.

The Contradiction Contour (CC) rises, falls and rises, just like RFR. It has been described by Pierrehumbert & Hirschberg (1990) as L* L-H%, and by Constant (2012) as L*(+H) L-H%. We believe a more accurate representation might be H+L* L-H% since CC utterances necessarily begin with either a high rise or a high-falling head before falling to the L* pitch accent (cf. Ladd 1980). In terms of meaning, CC takes *p* as input, and returns *p* as output while requiring contextually salient evidence for $\neg p$ (cf. Liberman & Sag 1974, Goodhue & Wagner 2015). Note that utterances of *p* with RFR or CC intonation assert *p*. To the extent that one assumes that assertions are always intonationally determined,

Bartels's identification of assertion with L- captures the assertive component of RFR and CC better than Truckenbrodt's claim that H* indicates assertion. Under our working hypothesis, we could claim that RFRs and CCs are holistic tunes that have the meanings we described above *as well as* an assertive component.

Incredulity intonation, not pictured in figure (1), has been described by Hirschberg & Ward (1992) as L*+H L-H%, i.e. identical to RFR but with a larger overall pitch range. In fact, Hirschberg & Ward argue that RFR and incredulity intonation are one in the same contour, which according to them conveys (p. 243) "*lack of speaker commitment* to the appropriateness of a scale or scalar value evoked in the context." The difference between them is whether the speaker expresses lack of commitment about a scale or scalar value they themselves have evoked (RFR, glossed as 'uncertainty'), or about one evoked by someone else (incredulity). In a forced choice perception study, they found that the primary acoustic correlate that predicted which interpretation participants picked was the size of the overall pitch range with larger pitch ranges conveying incredulity. Putting Hirschberg & Ward's characterization of the meaning of incredulity contour into our own terms, it takes as input a proposition *p* and conveys that *p* is unexpected in the face of evidence for *p* or an interlocutor's commitment to *p*. Note that while RFR asserts *p*, incredulity does not. Since the two contain the same tones, this fact seems to support our position of specifying holistic intonational morphemes with the property of assertiveness rather than identifying that property with an individual tone.

Given our working hypothesis on intonational meaning, we are inclined to suggest that RFR and incredulity are indeed distinct intonational morphemes with distinct meanings. It just happens that the phonetic characteristics that distinguish them are not the shapes of the contours or the locations of pitch accents, but the maximum pitch values that the contours reach. However more work is needed to explore this issue. What is more interesting for present purposes is that our contexts, though compatible with both Hirschberg & Ward's and our characterization of incredulity contour, did not elicit a single one in production, as we will see below. Instead, we observed many incredulous YNrisers.

3. Production

As discussed, RFR, CC and incredulity all share similar phonetic forms, and certain authors have claimed that certain subsets of them are actually not distinct contours, e.g. Liberman & Sag (1974) have argued that RFR and CC are one contour. We wanted to answer questions (i) and (ii) from section 1 with this experiment: Do contexts befitting the meanings of these contours (as proposed in section 2) reliably elicit the expected contours from participants, and if so, with what frequency? Do these contexts elicit unpredicted contours? Therefore, we created contexts in which speakers intend to convey an incomplete response (conducive to using RFR), in which they intend to contradict a previous claim (conducive to CC), and in which they intend to express incredulity (conducive to both incredulity and YNrise). The rest of our stimuli can be found using the link in section 1.

(2) **Context sentences and [stage directions]** (1 example set of 9 different items):

a. **Incomplete Response**

Emma: I don't feel like going to this party tonight, I have the feeling I might not like any of the people there.

[You know your friend John is attending the party, and you know Emma knows and likes him, but you're not sure whether she'll like anyone else, and your answer should reflect that.]

Participant's response: You like John

b. **Contradiction**

Emma: So yesterday Sarah asked me if I was going to John's Birthday party and I said no, I don't even like him.

[Your friend Emma spent the whole day with John yesterday and you know for a fact that she likes him. So you're very surprised by what Emma says, and your answer should reflect that.]

Participant's response: You like John

c. **Incredulity**

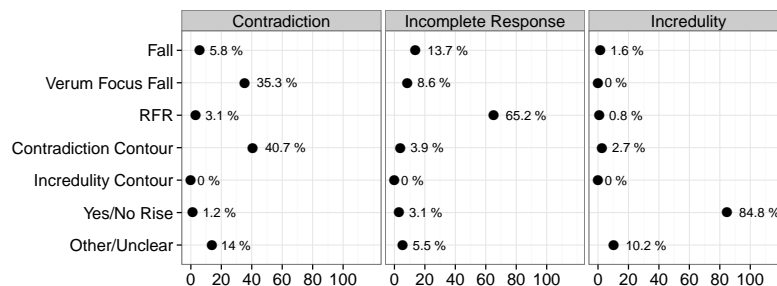
Emma: Yesterday Sarah kept saying mean things about John and I was really uncomfortable because John's a nice guy, I really like him.

[Just the other day your friend Emma was bad talking John, so you know for a fact that she doesn't like him. So you're very surprised by what Emma says, and your answer should reflect that.]

Participant's response: You like John

28 participants read the dialogue and stage directions clarifying their character's intentions. Then they heard a prerecording of the context sentence and were recorded producing the response in a sound-attenuated booth. Two RAs and the first and last authors annotated which tune was used in the 756 responses. The annotations were performed blind to context. There was a very high degree of agreement among annotators. Figure (3) shows the first author's annotation.

(3) *Percentages of contours produced for each condition*



The three contexts successfully elicited different contours, for the most part those expected by prior research. The most frequent contour used to contradict was CC (41%), followed by VF fall (35%). RFR (65%) appeared most frequently in incomplete response contexts. The most frequent contour found in incredulity contexts was YNrise (85%), often including an initial rise and fall on the subject, with virtually no occurrences of the incredulity contour.

Therefore, the answer to question (i), “Do speakers actually produce these tunes in the contexts said to license them, and if so with high frequency?”, the answer is *yes*, but with certain caveats. RFR is used with high frequency in our incomplete response contexts without competition from another contour well suited to such contexts. CC is used with high frequency in contradiction contexts, however there is another intonation in English that appears to be roughly as well suited to use in such contexts, what we have called VF fall. Note the low occurrence of falls with object prominence. There appears to be a strong preference to F-mark the polarity head when the sentence is already given in the context causing prominence to shift to the verb, but only for falls. In all occurrence of CC that we found, prominence remains on the object. In other words, the choice of focus marking and intonational contour are not independent of each other in this case, people either shift prominence to the verb *or* use CC—a trade-off that is unexpected based on what we know about focus theory and the meaning of the contours involved.

The incredulity contour did not appear at all in our data. Instead, we found a high rate of emphatic YNrisers. The extra emphasis usually manifested as double prominence on the subject and object, with strong rises in each position, though a higher rise utterance finally (see figure (1)). Qualitatively, these YNrisers were very clearly incredulous. This impression might be caused by steeper rises, in turn caused by greater speaker involvement. Hirschberg & Ward (1992) make a similar argument, that the greater pitch range of incredulity contour is caused by greater speaker involvement, which explains the meaning difference between incredulity and RFR. I.e., the paralinguistic modulation of speaker involvement leads to a nontrivial change in the meaning of a conventionalized contour. In contrast, the greater emphasis we found in YNrisers, while adding an incredulous quality, do not seem to change the conventionalized meaning of the YNrise in that such utterances still question *p*.

Regarding question (ii), which other contours do speaker use in the contexts conducive to CC, RFR, and Incredulity respectively, the answer is that while a variety of contours are used in each context, these particular three contours were only used in the contexts they are predicted be used in. This result suggests that despite being phonetically similar, these rising contours are nevertheless distinct in form and meaning, so much so that participants do not produce them interchangeably and annotators can reliably distinguish between them. As for other contours, the frequency of VF fall in contradiction contexts is intriguing though not unexpected (cf. Goodhue & Wagner 2015, in which we found VF falls).

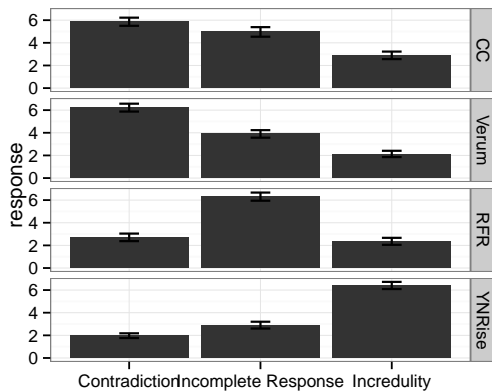
4. Perception

In the production study, we demonstrated that participants reliably produce these contours in the predicted contexts. But will naïve participants judge them as acceptable in the contexts in which they were originally produced? Moreover, are the tunes acceptable in other contexts (question (iii) from section 1)? We ran a perception study to test these questions. 15 participants listened to four contour types (CC, RFR, YNrise, and VF fall) as part of a dialogue in all three original contexts. They were asked to “Please rate how natural the response sounded given the question (1=completely unnatural, 8=completely natural)”.

All contours were rated highly natural in their original contexts, and YNrise and RFR are not rated highly out of their original contexts (see figure (4)). CC was judged fairly

natural in incomplete response contexts as well. This result makes sense when we consider that most interlocutor utterances in incomplete response contexts may be taken to imply $\neg p$, which licenses the CC on p . For example, in (2a), suppose it is common knowledge that John will be at the party, then the participant can combine this information with Emma's utterance to infer that Emma implies that she doesn't like John. This inference then can license the use of the CC on the response. In other words, it is easy to see why the CC might be deemed compatible with the RFR context in the perception study, even though nothing about the context itself suggests a contradiction, and our stage directions made it unlikely that our speakers would take it to be a contradictory response. Under our interpretation of the CC, the result shows then that this contour does not require $\neg p$ to be overtly uttered in order to be licensed, it can just be implied by what was said in the context.⁴

(4) *Naturalness Ratings*



Meanwhile, VF fall is not rated as highly as CC in incomplete response contexts. As we stated in section 2, we believe verum focus is just focus on the polarity head, which requires the sentence it appears with the be given in the context. Since p is not given in the incomplete response contexts, it makes sense that verum focus would be less acceptable. It seems that in contrast to the CC, prosodic focus marking requires overt antecedents.

It is interesting to note that the one overlap in compatibility (CC is acceptable in RFR-conducive contexts) does not correspond to the greatest phonetic similarity between two contours. Looking at figure (1), we can see that CCs and RFRs were not particularly similar in form in the results of the production experiment. Nevertheless, CC is rated highly acceptable in RFR-conducive contexts. On the other hand, YN rises almost always featured a double rise that rendered them phonetically similar to the CC. The difference between the two contours is that the initial rise was higher than the final rise in CCs and vice versa for YN rises. In fact, there were a few observations that were very difficult to annotate in which the initial and final rise were roughly equal. Nevertheless, CC was not judged acceptable in incredulity contexts, nor was YN rise rated acceptable in contradiction contexts. Therefore,

⁴Of course, another possibility is that we have not accurately characterized the meaning of CC, and still another is that participants interpreted CC as a different contour when heard in incomplete response contexts.

the acceptability of one contour in another contour's context appears to be driven by the meaning attached to these contours, not by superficial similarity in form.

5. Discussion and future directions

Our results are reassuring: Intonational contours that prior studies have argued are used to contradict or to insinuate are actually used very reliably when this is the intention that speakers have, even when this intention is just implanted by a set of stage directions in an experimental and somewhat artificial setting, and even though our speakers were unaware that the experiment is about intonation. They also provide for the first time a quantitative look at which contours speakers are likely to use in relevant types of contexts. The CC and the RFR are in fact the most frequent contour in the contexts designed to motivate them—which is more than we were hoping for when designing this study. After all, there are many contours to choose from, some of which maybe not yet be properly identified. Our contradiction contexts made both the CC and VF fall likely, but we saw in the perception experiments that the conditions on their use still differ.

The one exception to this result is the incredulity contour, which turned out to be elusive. One possible reason for this is that incredulity contour is, unlike CC and RFR, a rare and exotic creature. Another possibility is that there is some subtle aspect to incredulity contour's meaning that is excluded by our experimental contexts. One possibility is that incredulity contour on p requires the speaker to accept their interlocutor's claim that p despite being surprised by it. In all of our incredulity contexts, the participant's characters did not merely expect $\neg p$, but believed that they knew $\neg p$ to be the case. Then the speaker was confronted with a claim that p . It may be that we made the speaker's evidence for or belief in $\neg p$ too strong. Perhaps speakers only use incredulity contour when the evidence for p is quite good, though surprising. We plan to test this hypothesis in future work.

We have not discussed various contours that we labeled in our 'other' category, which would merit some discussion. As we said, we see the analysis of this data as a work in progress. Different annotation schemes should be used, and different acoustic analyses should be undertaken. We hope that this study will inspire other researchers to engage with this data and add their own interpretation, and maybe run similar studies. Ultimately, we want to identify all contours of English, for which we will need to look at a much broader range of contexts, leading to a more complete bestiary of tunes.

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