Rightward movement affects prosodic phrasing[1]

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1. Introduction

The same linear string can often be rendered with a prosodic boundary in a given position, or without that boundary. In the examples in (1), for instance, prosodic boundaries optionally are placed at the indicated positions (Taglicht 1998).

(1) a. Everyone knows (||) that this is not true.
    b. She gave her friend (||) an interesting book.
    c. We know that this charge (||) is completely baseless.

If the same string can be prosodically rendered in different ways, the question is raised: how directly does prosodic phrasing reflect syntactic constituency structure?

In this paper, we consider cases where prosodic phrasing seems to be conditioned by factors other than syntactic constituency, and argue that these cases in fact involve choices between alternative syntactic structures conveying the same meaning, a position similar to that taken in Steedman (1991, et seq.). In particular, we consider the effects of rightward movement in the syntax on prosodic phrasing, and argue that rightward movement can account for otherwise unexpected distributions of prosodic boundaries.[2]

In the first part of the paper (§2-4), we consider the syntactic and prosodic properties of parenthetical adverbs (e.g. *fortunately*, *please*). We report experimental results suggesting that prosodic boundaries following parenthetical adverbs, which prior

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[1] We are grateful to Martin Hackl, Danny Fox, and the audience at NELS 45 (MIT) for helpful feedback. We also thank the members of prosody.lab for their help with data collection and analysis. AH is partially supported by a SSHRC doctoral fellowship; this research was also supported by SSHRC 410-2011-1062 on Relative Prosodic Boundary Strength, funds from the Canada Research Chair and CFI programs, and a fellowship from the Alexander von Humboldt Foundation to MW. All errors are our own.

[2] We are not the first to propose such an analysis. Bing (1985, 43) reports on a conference paper given by Mark Liberman in 1978 at UMass Amherst, in which he argued that “that a transformation similar to that of Right Node Raising” can account for certain apparent mismatches between syntax and prosody.

research attributed to a "comma morpheme" (Potts 2005, Selkirk 2005), can in fact be derived from their syntactic attachment, once rightward movement is taken into account.

The parenthetical results motivate a view where an XP that undergoes rightward movement to adjoin to TP is systematically preceded by a prosodic boundary. This offers a way to account for the optional boundaries in (1): in (1a), *that this is not true* optionally undergoes rightward movement to adjoin to TP, and is preceded by a boundary just in case this movement takes place (§5).

In the final part of the paper (§5.1-6), we apply the idea that optionality in prosodic phrasing reflects optionality between different syntactic structures to resolve a puzzle from Hirsch & Wagner (2015) related to how reliably speakers produce prosodic cues to resolve PP-attachment ambiguities.

2. Parenthetical adverbs

Certain adverbs can appear at different positions in the linear string. These include *fortunately* in (2) and *please* in (3), which relate to speaker attitude or intention.

(2) a. **Fortunately** the scientists discovered the cure on Thursday.
b. The scientists discovered the cure **fortunately** on Thursday.
c. The scientists discovered the cure on Thursday **fortunately**.

(3) a. **Please** tap the frog with the flower.
b. Tap the frog **please** with the flower.
c. Tap the frog with the flower **please**.

When the adverb follows the main predicate in (2b) and (3b), there is a signature prosody: the adverb is followed by a strong boundary ('||'), and is itself often rendered with low prominence or prosodically subordinated (Wagner 2005; indicated with italics).

(4) a. The scientists discovered the cure *fortunately* || on Thursday.
b. Tap the frog *please* || with the flower.

There are at least two way to account for how these adverbs come to appear at different linear positions, and correspondingly, at least two ways to account for the boundary in (4). We argue for an approach where the adverb uniformly adjoins to TP, and (2/3b) involve rightward movement of the final PP modifier to a position above the adverb. The boundary then links to this rightward movement.

3. Two analyses of parentheticals

We spell out the two analyses for the syntax and prosody of parenthetical adverbs, and propose a way to dissociate them, which we then implement experimentally.

3.1. Analysis 1: syntactic variability + comma morpheme

Taking (3) as illustrative, one approach to the syntax of *please* holds that *please* can occur in different linear positions because it can attach at different positions in the syntactic hierarchy. For instance, it could be that *please* can attach at any position on the clausal spine. When *please* occurs at the beginning (3a) or end (3c) of the sentence, it is adjoined to TP; when it occurs in parenthetical positions, as in (3b), it is adjoined to *v*P.

If *please* is adjoined to *v*P in (3b), the boundary following *please*, as in (4b), requires additional explanation not linked to the syntax: *with the flower* would also be a *v*P adjunct, and typically, *v*P adjuncts do not require a boundary separating them. This is illustrated in (5) with the *v*P adjuncts *quickly* and *with care*.

(5) Tap the frog quickly (||) with care.

Potts (2005) and Selkirk (2005) treat the boundary following parentheticals as the phonological exponent of a morpheme, comma, which co-occurs with the parenthetical. The boundary in (3b) is thus a reflex of lexical information, rather than syntactic information, on this approach.

3.2. Analysis 2: rightward movement

An alternative approach to the syntax of parentheticals holds that *please* attaches at the same syntactic height in all of (3a)-(3c), possibly as an adjunct to TP. Because *with the flower* is a *v*P adjunct, if *please* is adjoined to TP, then it must be that *with the flower* in (3b) is pronounced to the right of *please* by attaching high, above *please*. We hypothesize that *with the flower* undergoes rightward movement from a *v*P internal position to adjoin to TP.

To illustrate, the structure for (3c) is given in (6), and the structure for (3b) is given in (7): (3b) is derived from (3c) by rightward movement of *with the flower*.

(6) *Structure for (3c) (final 'please')*
[$_{TP}$ [$_{TP}$ tap the frog with the flower] please]

(7) *Structure for (3b) (parenthetical 'please')*
b. [$_{TP}$ [$_{TP}$ [$_{TP}$ tap the frog t_k] please] with the flower$_k$]]]

We can now derive the prosody in (3b) directly from the syntax. The relationship between syntax and prosody could be modeled in several ways, each of which links the boundary in (3b) to the status of the constituent following *please* (*with the flower*).

First: it could be that the right edge of a TP maps to a boundary. Because *with the flower* is adjoined to TP, *with the flower* would then be preceded by a boundary, as observed. Since *please* is also adjoined to TP, this additionally predicts a boundary preceding *please*. In fact, this boundary is often not felt, because, as indicated above, *please* can – or maybe must – be reduced in prominence whenever it right-adjoins to TP. Final *please*, for example, is incapable of carrying main sentence prominence.

Second: Wagner (2005) proposes a cyclic spell-out algorithm, which predicts that constituents merged within a cycle are offset from each other by boundaries stronger than the boundaries due to cycles contained in them. Assuming *v* is a cyclic node, adjuncts to TP – like *with the flower* – are spelled out on a higher cycle than phrases within the *v*P, and accordingly should be offset by relatively stronger boundaries.

Third: it could be that rightward movement itself induces a boundary preceding the moved constituent. Because *with the flower* undergoes rightward movement, *with the flower* would again be preceded by a boundary.

In any of these approaches, the boundary in (3b) is ultimately derived because *with the flower* undergoes rightward movement: by the first and second approaches, rightward movement affects the prosody indirectly because it results in *with the flower* being adjoined to TP, and this induces the boundary; by the third possibility, rightward movement of *with the flower* is directly responsible for inducing the boundary.

3.3. Dissociating the analyses

The goal now is to dissociate Analysis 1 and Analysis 2 to test whether the observed boundary in (3b) in fact links to rightward movement, per Analysis 2. The analyses make distinct predictions about prosodic rendering when there are two constituents to the right of the adverb. The schema is given in (8):

(8) … ADV XP1 XP2

By Analysis 1, ADV can attach as a *v*P adjunct, and induces a boundary immediately following it by virtue of the comma morpheme with which it co-occurs. Assuming that XP1 and XP2 are both also *v*P adjuncts, then the predicted prosodic rendering for (8) is (9), with the sole boundary the one introduced by comma:

(9) … ADV || XP1 XP2

By Analysis 2, ADV is adjoined to TP, and XP1 and XP2 can only follow it if they attach high. If any high-attached phrase is preceded by a boundary, then high-attachment of XP1 will induce a boundary preceding it, and similarly for XP2. The predicted rendering is thus (10), with two boundaries, rather than one:

(10) … ADV || XP1 || XP2

4. Experiment 1: rightward movement affects prosodic phrasing

We experimentally dissociate the two analyses of the syntax and prosody of parentheticals by testing which makes the correct prediction for the rendering of a schema like (8): do participants render (8) with one boundary, or two?

We consider sentences like (11a), which contains two PPs. As will be discussed further later in the paper, (11a) displays a structural ambiguity in the attachment site of the PPs. For Exp. 1, however, we are interested only in a reading where both PPs attach as *v*P adjuncts. The reading is paraphrased in (11b), and biased by the context in (12): *with the flower* is interpreted as an instrument, and *on the hat* as a goal.

Please is introduced into the test sentences at different linear positions in three experimental conditions: in Condition 1, *please* precedes both PPs, as in (12a); in Condition 2, *please* intervenes between the two PPs, as in (12b); in Condition 3, *please* occurs at the end of the sentence, as in (12c). 9 items were created in analogy to (12).

(11) a. Tap the frog [with the flower] [on the hat].
b. Tap the frog by using a flower, and tap it on the hat that it's wearing.

(12) John is in the forest. He sees a frog who is wearing a hat. There is a flower nearby. You want John to take the flower and use it to tap the frog's hat. This is what you say to him:
a. Tap the frog **please** with the flower on the hat. (early *please*)
b. Tap the frog with the flower **please** on the hat. (late *please*)
c. Tap the frog with the flower on the hat **please**. (final *please*)

4.1. Task

The experiment uses a planned production paradigm. Participants (n=18) were presented with a context like that in (12) followed by a target sentence like (12a)-(12c). They were instructed to read the context and sentence silently to themselves, and then to record themselves reading the sentence aloud. Recordings were made in a sound attenuated booth in the prosody.lab at McGill University.

4.2. Predictions

The critical condition is the early *please* condition in (12a), where both PPs are to the right of *please*. (12a) is a realization of the schema in (8).

As seen in §3.3, Analysis 1 predicts that participants will render (12a) with a single prosodic boundary induced by a comma morpheme co-occurring with *please*:

(13) *Analysis 1: one boundary in (12a)*
Tap the frog please || with the flower on the hat.

Analysis 2 leads to a different prediction, though some complications particular to this example need to be considered, adding to the discussion from §3.3. By Analysis 2, (12a) is derived if *with the flower* and *on the hat* undergo rightward movement above *please*. The predicted prosody depends on whether they each move separately above *please*, or move together as a constituent. If they move separately, then the prediction is as discussed in §3.3: *with the flower* moves to adjoin to TP, and *on the hat* moves to adjoin to TP, and each of them is then preceded by a boundary.

(14) *Analysis 2: two boundaries in (12a) if PPs move separately*
Tap the frog please || [with the flower] || [on the hat].

If, however, *with the flower on the hat* moves as a constituent, then that constituent itself adjoins to TP, and is preceded by a single boundary, per (15), convergent with (13).

(15) *Analysis 2: one boundary in (12a) if PPs move as a constituent*
Tap the frog please || [with the flower on the hat].

Whether (14) or (15) obtains depends on the analysis of the two PPs in their base positions. One possibility is that *with the flower* adjoins to *v*P, and *on the hat* above:

(16) [$_{\text{TP}}$ [$_{v\text{P}}$ [$_{v\text{P}}$ [$_{v\text{P}}$ tap the frog] with the flower] on the hat] please]

Because *with the flower* and *on the hat* do not form a constituent in (16), the only option to derive (12a) is for each of them to move separately above *please*, and (14) obtains.

A second possibility is that the *v*P domain has a right-branching structure (e.g. Larson 1988, Pesetsky 1995). In Larson's analysis, the VP contains a series of shells, each embedded in the last: *with the flower* attaches in a VP shell below *the frog*, and *on the hat* attaches in a more deeply embedded VP shell, per the (simplified) structure:

(17) [$_{\text{TP}}$ [$_{v\text{P}}$ tap [$_{\text{VP}}$ the frog [$_{\text{VP}}$ with the flower [$_{\text{VP}}$ on the hat]]]] please]

Unlike in (16), *with the flower* and *on the hat* are contained in a constituent in (17). If that constituent itself moves above *please*, (15) obtains. If *on the hat* undergoes rightward movement on its own, and the constituent containing *with the flower* and the trace of *on the hat* undergoes rightward movement separately, (14) obtains.

The crucial upshot is that Analysis 1 predicts the test sentence in the early *please* condition to necessarily be rendered with a single boundary, whereas Analysis 2 predicts either two boundaries (14), or optionality between one (15) and two (14) boundaries.

The predictions for the late position of *please* in (12c) are very different: both analyses converge in predicting that the sentence will be rendered with a single boundary:

(18) *Both analyses: one boundary in (12c)*
Tap the frog with the flower please || on the hat.

By Analysis 1, the comma morpheme induces a single boundary following *please*. By Analysis 2, *on the hat* undergoes rightward movement above *please*, so is obligatorily preceded by a boundary; being to the left of *please*, *with the flower* has not necessarily undergone rightward movement, so is not obligatorily preceded by a boundary.

A crucial prediction is thus derived. By Analysis 1, the likelihood of participants producing two boundaries in the early *please* condition should not differ from the late *please* condition: in both, only a single boundary is predicted. By Analysis 2, the two conditions should differ: participants should be more likely to produce two boundaries in the early *please* condition than in the late *please* condition.

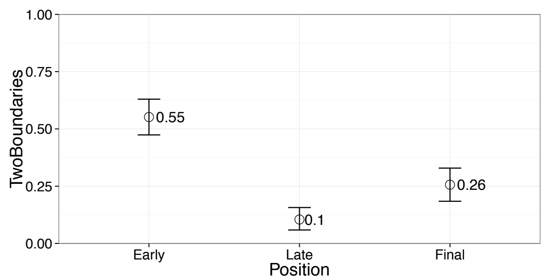
4.3. Results

Three annotators (including both authors) listened to the recorded sound files from the production experiment and perceptually coded whether the participant produced the test sentence with two boundaries; a single boundary; or no boundaries. We also forced-aligned the data to a phonetic transcription using the prosodylab.aligner (Gorman et al. 2011), and extracted acoustic measures for words of interest. We discuss results from the perceptual annotation (§4.3.1), and the acoustic results (§4.3.2) in turn.

4.3.1. Perceptual annotation

The proportion of utterances perceptually coded as having two boundaries is reported in Fig. 1.[3] In the late *please* condition, the rate of two boundary productions is near floor, as expected under both analyses. In the critical late *please* condition, participants produce two boundaries in approximately half of the trials. This result contradicts Analysis 1, and is consistent with Analysis 2: participants are more likely to render the late *please* condition with two boundaries than they are the early *please* condition.

(19) *Fig. 1: Proportion of two boundaries according to perceptual annotation*



We fit a logistic mixed effects regression model using lme4 (Bates et al. 2014) with random intercepts and slopes for item and participant. Using Helmert coding for the position of *please*, we made two comparisons: *final* vs. *non-final* position, and critically, *early* vs. *late*. The model finds a significant difference between early and late ($p < 0.001$, estimated with the Satterthwaite approximation, using lmerTest, Kuznetsova et al. 2013).

4.3.2. Acoustic data

The experimental materials made it impossible to perceptually annotate the data without it being transparent to the annotator which experimental condition a soundfile stemmed from: the position of *please* made that obvious. In order to ensure that the perceptual results are not an artifact of biases in the annotation, we looked at the acoustic realization of the boundaries, as reflected by pre-boundary lengthening on the words preceding them (*frog* for a boundary preceding *with the flower*; *flower* for *on the hat*).

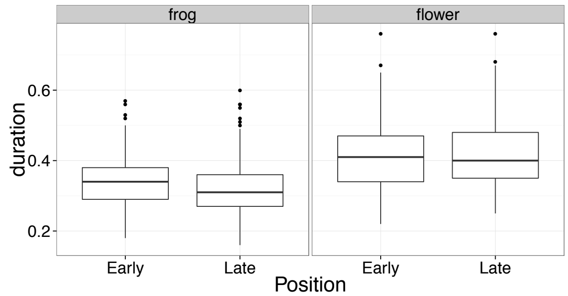
By Analysis 1, there should be a boundary before *with the flower* only in the early *please* condition, and a boundary before *on the hat* only in the late *please* condition. So, acoustically, *frog* should have greater duration in early than late and vice versa for *flower*.

By Analysis 2, there should be a boundary before *with the flower* only in the early *please* condition, and a boundary before *on the hat* both in the early *please* condition and, at least optionally, in the late *please* condition. So, *frog* should be of greater duration in early than late, while *flower* may be of similar duration in both.

The duration of *frog* and *flower* in the early and late *please* conditions is plotted in Fig. 2, which shows that the prediction of our proposal (Analysis 2) is borne out: a difference between the early and late conditions is visible on *frog*, but not on *flower.*

[3] We used the perceptual annotation that correlates best with the results of the acoustic analysis, which was that of the second author, but the other annotations were qualitatively similar.

(20) *Fig. 2: Durations of pre-boundary words for the two boundaries*



We pooled the measures for *frog* and *flower*, and coded a predictor ('Boundary Prediction') that was set to 1 where Analysis 1 predicts a boundary: *frog* in early and *flower* in late were coded as 1; *flower* in early and *frog* in late were coded as 0. We fit a linear mixed effects model predicting duration from the interaction of Boundary Prediction (1 vs. 0) and Word (*frog* vs. *flower*), with random intercepts and slopes for items and participants. Analysis 2 predicts an interaction: because *frog* precedes a boundary in early but not late, and *flower* may precede a boundary in both, Boundary Prediction 1 should have greater duration than 0 for *frog*, but not *flower*. Analysis 1 predicts no interaction: because *frog* is preceded by a boundary only in early and *flower* only in late, Boundary Prediction 1 should have greater duration than 0 for both words. A significant interaction is observed ($p<0.03$, with model comparison), per Analysis 2.

4.4. Discussion

Both the perceptual and acoustic results show significant effects expected if early vs. late placement of *please* has asymmetric effects on prosody: early placement leads to two boundaries; late placement leads to a single boundary. This is predicted by Analysis 2, where constituents following *please* undergo rightward movement, and the distribution of prosodic boundaries links to rightward movement. The results of Exp. 1 are significant in two ways: (i) they show that the prosody of parentheticals links to the syntax, rather than to lexical information (comma), and (ii) they motivate the generalization in (21).

(21) *Rightward movement affects prosodic phrasing*
Rightward movement of an XP to adjoin to TP induces a boundary preceding XP.

5. Optional prosodic boundaries = optional rightward movement

We pursue the idea that (at least certain) optional boundaries, when present, are induced by the same mechanism as the boundaries with parentheticals: rightward movement, per the generalization in (21). Recall the examples in (1), repeated as (22):

(22) a. Everyone knows (||) that this is not true.
b. She gave her friend (||) an interesting book.
c. We know that this charge (||) is completely baseless.

By our hypothesis, the optionality of the boundary in (22a) reflects an option between two alternative syntactic structures: one with *that this is not true* in situ in the *v*P (no boundary), and one with *that this is not true* extraposing to adjoin to TP (boundary).

This approach gains traction when examples like (23) are considered, which show that the distribution of optional prosodic boundaries is syntactically constrained:

(23) *But [$_{DP}$ almost || all of them] knew that. *(Taglicht 1998)*

One way to derive the boundary in (23) would be for *all of them knew that* to undergo rightward movement. This string, however, does not form a constituent, and so is not eligible for movement, and the phrasing in (23) cannot be derived.

In the remainder of the paper, we argue that the hypothesis that optional prosodic boundaries reflect optional rightward movement resolves a paradox having to do with the conditions under which speakers prosodically resolve PP-attachment ambiguities. We introduce the paradox (§5.1) and our account for it (§5.2), and then provide experimental support for the idea that rightward movement is involved (§6).

5.1. The paradox

The sentence in (24) shows a well-known ambiguity in the interpretation of the PP *with the flower*. The PP may convey that the flower is the instrument to be used to tap the frog, as in (24a), or that the frog to be tapped is the one holding the flower, as in (24b).

(24) Tap the frog with the flower. (Snedeker & Trueswell 2003)
  a. Tap the frog by using the flower. *(instrument reading)*
  b. Tap the frog who has the flower. *(NP modifier reading)*

The instrument reading obtains when the PP attaches as a *v*P-level adjunct, and the NP modifier reading obtains when the PP is an adjunct in the NP headed by *frog*.

Since Lehiste (1973), it has been known that speakers can signal the intended reading in cases of structural ambiguities like that in (24) by modulating the placement of prosodic boundaries. A relatively stronger boundary before the PP than after the verb signals the instrument reading, and vice versa signals the NP modifier reading.

(25) a. Tap the frog || with the flower. *(favoring instrument reading)*
  b. Tap || the frog with the flower. *(favoring NP modifier reading)*

Experimental results conflict, however, as to whether speakers consistently prosodically disambiguate ambiguities in PP attachment. Snedeker & Trueswell (2003, ST) report that speakers differentiate (24a/b) only when both readings are relevant in the context, and possibly only when they are consciously aware that the sentence is ambiguous. On the other hand, Kraljic & Brennan (2005, KB) report that speakers differentiate (26a/b) independent of factors like ambiguity in context and awareness.

(26) Put the dog [in the basket] on the star.
  a. Put the dog into the basket that is on the star.
  b. Put the dog that is in the basket onto the star.

KB suggest that the divergence in results between their experiment and ST's might be due to differences between their respective tasks. Hirsch & Wagner (2015, HW), however, replicate the conflicting results within a single experiment, suggesting that there is something intrinsically different about the two ambiguities.

HW considered sentences like the ones from Exp. 1, but without *please*, as in (27), and looked at three different readings of these sentences, as in (27a)-(27c).

(27) Tap the frog with the flower on the hat.
  a. Tap the frog that has a flower and tap it on its hat. ('left')
  b. Tap the frog by using a flower and tap it on its hat. ('list')
  c. Tap the frog by using the flower that is on the hat. ('right')

HW conducted an experiment in which participants produced (27) in the presence of a written context disambiguating one of the three readings. The context biasing (27a) was the same as in (12) above; additional contexts were used biasing (27b) and (27c).

How aware participants were of the ambiguity was manipulated between two groups of participants. In one group ('high aware'), participants received explicit instruction about the ambiguity prior to the experiment, and the intended reading of the sentences was manipulated as a within-subject variable, so the ambiguity was salient to a given participant in the task. In the second group ('low aware'), participants did not receive explicit instruction, and the intended reading of the sentences was manipulated as a between-subject variable; this way, a given participant was exposed to only one reading, making the ambiguity less salient.

Participants in the high aware group prosodically differentiated all three readings: (27a)-(27c) were rendered as in (28a)-(28c), respectively.

(28) a. Tap the frog with the flower || on the hat. (27a > left prosody)
  b. Tap the frog || with the flower || on the hat. (27b > list prosody)
  c. Tap the frog || with the flower on the hat. (27c > right prosody)

Participants in the low aware group continued to prosodically differentiate (27a) and (27c), but their prosodic rendering of (27b) neutralized with that of (27a): they often conveyed (27b), as well as (27a), with a left prosody.

In this way, HW observe a result similar to the conflict between ST and KB within a single experiment: participants reliably disambiguate (27a) and (27c), but not (27a) and (27b). The difference between the two ambiguities is our paradox.

5.2. Accounting for the paradox

The puzzle in HW's results is the rendering of the list reading: a list prosody in the high aware group, and a left prosody in the low aware group. We propose to account for prosodic optionality with the list reading in the same way we accounted for optionality in the examples in (22): the choice between renderings reflects a choice between syntactic structures differentiated by whether or not optional rightward movement takes place.

The base structure for the list reading is given in (29a), which has both PPs attached as *v*P-level adjuncts. Since both PPs attach at the same height, this structure corresponds to a list prosody, as in (29b): both PPs are preceded by boundaries of similar strength.

(29) *Base structure: list prosody*
a. [$_{vP}$ tap the frog [$_{PP1}$ with the flower] [$_{PP2}$ on the hat]]
b. Tap the frog || with the flower || on the hat.

The left prosody derives from the structure in (30a). PP2 extraposes from the *v*P to adjoin to TP, and this results in PP2 being preceded by a stronger boundary than PP1.

(30) *Structure with rightward movement of PP2: left prosody*
a. [$_{TP}$ [tap the frog [$_{PP1}$ with the flower] t_k] [$_{PP2}$ on the hat]$_k$]
b. Tap the frog with the flower || on the hat.

Since left prosody is the default when speakers are unaware of the ambiguity, if this account is right, it must be that the structure *with* rightward movement in (30a) is preferred to the base structure in (29a). The account thus rests on there being a *preference* for rightward movement. While we will not discuss this preference in detail, we take it that high adjunction of PP2 facilitates processing: it chunks the string into two separate units (*the frog* and *with the flower* in the *v*P domain, *on the hat* in the TP domain), providing a juncture at which the first two constituents can be interpreted.

5.2.1. Invariable prosody with the other readings

Why are the left and list readings consistently disambiguated in HW's experiment? The base structure for the left reading is given in (31a), and for the right reading in (31b):

(31) *Base structures for left and right readings*
a. [$_{vP}$ [tap [$_{DP}$ the frog with the flower]] [on the hat]] (left)
b. [$_{vP}$ [tap the frog] [with [$_{DP}$ the flower on the hat]]] (right)

As mentioned, Wagner (2005) links the strength of prosodic boundaries to cyclic spell out: the constituents merged within a cycle are offset from each other by stronger boundaries than the boundaries due to cycles contained in them. Assuming DP marks the edge of a cycle, the following is predicted, which generates predictions for (31a/b):

(32) A PP adjoined higher than a given DP is preceded by a stronger boundary than a PP contained within that DP.

In (31a), because PP2 is adjoined higher than the bracketed DP, and PP1 is contained within the DP, PP2 should be preceded by a stronger boundary than PP1. In (32a), PP1 should be preceded by a stronger boundary than PP2 for similar reasons. Thus, (31a) corresponds to a left prosody, and (31b) to a right prosody:

(33) *Prosodic predictions for the base structures in (31a/b)*
a. Tap the frog with the flower || on the hat. (31a > left prosody)
b. Tap the frog || with the flower on the hat. (31b > right prosody)

In this way, by their base structures, the left and right readings are predicted to be disambiguated. To account for why HW did not observe certain alternative renderings for left and right in the unaware group, there must be a *dispreference* for instances of rightward movement which would derive these renderings.

With the left reading, rightward movement of PP2 yields the structure in (34a), which has a prosodic rendering convergent with the base structure in (31a): left prosody.

(34) a. [$_{TP}$ [$_{vP}$ tap [$_{DP}$ the frog with the flower] t_k] on the hat$_k$]
b. Tap the frog with the flower || on the hat.

However, if PP1 and PP2 *both* extrapose to adjoin to TP, then each would be preceded by a boundary, deriving a list prosody, as in (35). Since the left reading is consistently rendered with a left prosody, rightward movement of both PPs must be dispreferred.

(35) a. [$_{TP}$ [$_{vP}$ tap [$_{DP}$ the frog t_k] t_j] [with the flower]$_k$ [on the hat]$_j$]
b. Tap the frog || with the flower || on the hat.

The situation is similar with the right reading. In this case, rightward movement of PP1 with PP2 embedded in it yields the structure in (36a), which corresponds to a left prosody, convergent with the base structure in (31b).

(36) a. [$_{TP}$ [$_{vP}$ tap the frog t_k] [with [$_{DP}$ the flower on the hat]]$_k$]
b. Tap the frog || with the flower on the hat.

However, if PP2 underwent rightward movement while PP1 remained internal to the *v*P, a left prosody would be derived, as in (37). Since a left prosody is not observed with the right reading, rightward movement of PP2 must be dispreferred.[4]

(37) a. [$_{TP}$ [$_{vP}$ tap the frog with [$_{DP}$ the flower t_k]] on the hat$_k$]
b. Tap the frog with the flower || on the hat.

5.2.2. Critical predictions

In summary, our account of HW's results rests on the following assumptions about which instances of rightward movement are (dis)preferred with each reading:

(38) a. **list:** rightward movement of *on the hat* is preferred.
b. **left:** rightward movement of *with the flower+on the hat* is dispreferred.
c. **right:** rightward movement of *on the hat* is dispreferred.

The dispreferences in (38a) and (38c) would be expected if it is dispreferred to extrapose a PP modifier out of an NP. Rather than directly testing this assumption, we use preferences in parenthetical placement to assess preferences for rightward movement.

[4] Some speakers in HW's unaware group did in fact render the right reading with a list prosody, but space prevents us from addressing this aspect of the results.

6. Experiment 2: diagnosing (dis)preferences for rightward movement

We consider again the sentences from Exp. 1, repeated:

(39) a. Tap the frog **please** [with the flower] [on the hat]. (early *please*)
b. Tap the frog [with the flower] **please** [on the hat]. (late *please*)
c. Tap the frog [with the flower] [on the hat] **please**. (final *please*)

This time, we cross the manipulation in the position of *please* with a manipulation of context like that in HW: different contexts are used to favor each of the three readings (left, list, right). Participants rate the naturaleness of (39a)-(39c) in the different contexts.

Given the conclusion from Exp. 1 that *please* adjoins to TP and achieves parenthetical placement when a constituent undergoes rightward movement above it, (39a)-(39c) differ in which constituents undergo rightward movement: in (39a), *with the flower* and *on the hat* extrapose above *please*; in (39b), *on the hat* extraposes; in (39c), neither *with the flower* nor *on the hat* extraposes. As such, the relative naturaleness of different placements of *please* can serve as a diagnostic for (dis)preferences as to which constituents undergo rightward movement. For instance, if (39b) were rated more natural than (39c), this would indicate a preference for rightward movement of *on the hat*.

From the predictions in (38a)-(38c), we expect the following (dis)preferences for parenthetical placement in Exp. 2: late *please* should be preferred relative to the other orders with the list reading; early *please* should be dispreferred with the left reading; and late *please* should be dispreferred with the right reading.

6.1. Method

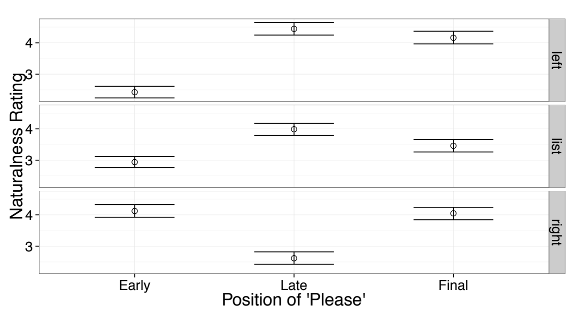
Participants (n=27) are presented with sentences like (39a)-(39c) in a context biasing one of the three readings, and are asked to rate how natural they find the sentence on a 7-point Likert scale (1 = completely unnatural, 7 = completely natural).

Items (n=9) were adapted from Exp. 1 and HW's experiment. Participants were presented with every combination of sentence type (early *please*, late *please*, final *please*) and context type (left, list, right) in pseudo-random order for a total of 36 trials.

6.2. Results and discussion

The mean naturaleness rating for each sentence type and context type is plotted in Fig 3.

(40) *Fig. 3: Naturalness ratings for the different positions of please by the context*



The observed pattern bears out our predictions. With the list reading, the late position of *please* (which requires rightward movement) is indeed preferred to early ($p<0.001$) and final ($p<0.05$) (tested with a cumulative link model for the subset of data with list syntax). The preference for left prosody in HW's low aware group can thus be explained by a structural preference for a high attachment of the final PP. Early *please* and late *please* are dispreferred for the left and right reading respectively, as expected since they would require a syntactic bracketing leading to a prosodic rendering not observed in HW's experiment.

7. Conclusion

We have argued that certain cases where prosodic phrasing appears to mismatch syntactic structure are in fact supportive of a direct relationship between syntax and prosody once effects of rightward movement are considered: an XP which undergoes rightward movement to adjoin to TP is preceded by a boundary. This accounted for the prosody of parentheticals, and for variability in the rendering of the list reading in HW's experiment.

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