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Subject/Object Complexity and Prosodic Boundary Strength in Irish

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Abstract

This paper reports on the results of a production experiment examining the rhythmic properties of prosodic boundaries in VSO (transitive) sentences in Connemara Irish. Specifically, word duration and the presence and duration of prosodic pauses were examined in two locations while manipulating the relative complexity of the subject and object: (a) between V and S and (b) between S and O. It was found that there is evidence for a prosodic boundary between S and O but little evidence for a prosodic boundary between V and S, and further, that the relative strength of the prosodic boundary between S and O increases with the complexity of both the subject and the object. It is proposed that the observations can be accounted for under a model that assumes that the location of prosodic boundaries is determined by syntactic structure and principles of syntax-prosody mapping, while the relative strength of these boundaries is a function of processing load and production planning.

Index Terms: prosodic boundary strength, syntax-prosody interface, Irish

1. Introduction

This paper reports on the results of a production experiment examining the rhythmic properties of prosodic boundaries in transitive sentences in the Connemara dialect of Irish (henceforth Irish), which have the word order Verb-Subject-Object (VSO). Specifically, word duration and the presence and duration of prosodic pauses were examined in two locations in VSO sentences: (a) between the verb and the subject, and (b) between the subject and the object. The relative complexity of the subject and the object was systematically manipulated to contain between one and three words.

The location of the prosodic boundary is of interest based on the assumption that the demarcation of prosodic boundaries is at least partially determined by syntactic constituent structure (for example, [1-4], among many others). Syntactically, Irish VSO sentences have the constituent structure [V[SO]], such that S and O together form a syntactic constituent to the exclusion of V [5-8].

Two hypotheses will be considered in this paper. The first is that the prosodic boundary between V and S (henceforth Juncture 1 or J1) should be larger than that between S and O (henceforth J2), because S and O are syntactically "closer" than V and S [3, 9-11]. The second is that the stronger boundary should be at J2 rather than J1, because the subject is phrasal in the syntax (a DP). Under a theoretical framework such as Match Theory [4, 12-14], syntactic phrases are predicted to map to phonological phrases (φ). If there is a phonological phrase boundary at the right edge of the subject but not at the right edge of the verb, we might therefore expect there to be a stronger prosodic boundary at J2 as compared to J1.

In addition, the relative complexity of the subject and object were systematically manipulated to contain between one and three words. This was done in order to test the hypothesis that processing load and production planning can affect the relative strength of prosodic boundaries. It has frequently been observed in the psycholinguistic literature [10, 15-18] that the relative strength of prosodic boundaries increases relative to the complexity of the material immediately preceding the prosodic boundary (reflecting the need for a refractory period), as well as to the complexity of the upcoming material (as a function of production planning). If the phonetic implementation of prosodic boundary strength is subject to factors such as processing load and production planning, we predict that the relative strength of the putative prosodic boundaries at J1 and/or J2 will increase with the complexity of the subject and object.

2. Methods and Materials

2.1. Materials and design

The production experiment had a 3x3 design which varied the number of words in subject and object position in the sentence between one and three words, for a total of 9 conditions. The design of the experiment is shown in Table 1. Syntactically, S and O consisted of either noun-adjective constructions (N, NA, NAA, as illustrated in Table 1) or possessive constructions optionally modified by an adjective (N, NN, NAN). These two constructions were systematically crossed across all items.

Table 1. *Experimental design*

	O=1	O=2	O=3
S=1	V [N] [N]	V [N] [NA]	V [N] [NAA]
S=2	V [NA] [N]	V [NA] [NA]	V [NA] [NAA]
S=3	V [NAA] [N]	V [NAA] [NA]	V [NAA] [NAA]

The experiment was run on 8 native speakers of Connemara Irish. All participants were fully bilingual with English, which is necessarily the case for all speakers of Irish today. A total of 12 items were used in the experiment, for a total of 12 items x 9 conditions x 8 participants = 864 possible tokens.

The experiment was a self-paced reading task, where each target sentence was presented in pseudo-random order using Irish orthography on a laptop computer running PsychToolBox for Matlab, and was recorded in a quiet room in the Acadamh na hOllscolaíochta Gaeilge in Carraroe, Ireland. Participants were in full control of starting and stopping the recording, and

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were given the option of re-recording the sentence in the case of a disfluency. Sentences were presented without context in order to achieve an "all-new" information structural context. All written instructions were given in Irish.

The experimental items were designed to facilitate durational measurements at two locations: following V (J1) and following the last word of the subject (J2). Verbs were always disyllabic and in the present tense, ending with the suffix –[ən] (-*(e)ann*). For subjects with noun-adjective constructions (N, NA, NAA), N in the S=1 conditions were chosen to be phonologically identical or as similar as possible to the adjective. For example, in the sample item given below in Table 3, *Neasa* (a proper name) is used in S=1 conditions, and *deasa* ('nice-PLURAL') is used in S=2 and S=3 conditions. For subjects in possessive constructions (N, NN, NAN), the noun was kept constant across conditions. All materials were checked by two native speakers of Irish before being presented in the experiment.

In addition, word length was controlled for by selecting disyllabic words as much as possible and by minimizing the use of function words, which were only used in the context of possessive constructions, where they are obligatory. Irish word stress regularly occurs on the initial syllable in Connemara Irish. Syllable weight and segmental content was not otherwise controlled for in the experiment.

Table 2 and Table 3 provide the gloss/translation and the full paradigm, respectively, for one of the items used in the experiment.

Table 2. *Translation and gloss of sample item*

Piocann	páistí	lácha	deasa	úlla	áibí	úra
pick.pres	children	kind	nice	apples	ripe	fresh
'Nice, kind children pick ripe, fresh apples.'						

Table 3. *Sample item across conditions*

Cond	V	S			O		
		N1	A2	A3	N4	A5	A6
1	Piocann	Neasa			úlla		
2	Piocann	Neasa			úlla	áibí	
3	Piocann	Neasa			úlla	áibí	úra
4	Piocann	páistí	deasa		úlla		
5	Piocann	páistí	deasa		úlla	áibí	
6	Piocann	páistí	deasa		úlla	áibí	úra
7	Piocann	páistí	lácha	deasa	úlla		
8	Piocann	páistí	lácha	deasa	úlla	áibí	
9	Piocann	páistí	lácha	deasa	úlla	áibí	úra

2.2. Measurements

In the transitive (VSO) sentences considered in this study, two possible locations for prosodic boundaries were compared: (a) Juncture 1 (J1) between the verb and the first word of the subject and (b) Juncture 2 (J2) between the last word of the subject and the first word of the object. In this study, only durational measures for prosodic boundary strength were considered, specifically, the duration of the word preceding the (putative) prosodic boundary at J1 and J2 (V and the last word in S, respectively), and the relative likelihood and duration of prosodic pauses at each location. Pauses were considered to be any non-zero instance of silence. Figure 1 provides a sample pitch track and illustrates the points of measurement.

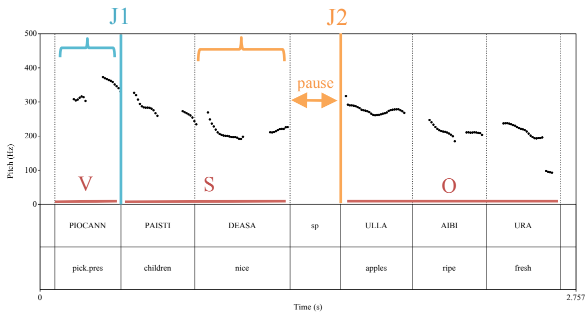

Figure 1: *Sample pitch track and measurement points.*

Word-level segmentation was produced automatically using a forced aligner (the prosody-lab aligner [19]). The aligner was trained using Irish production data (including data from other experiments) and was hand-checked and corrected for alignment errors. All tokens with disfluencies or obviously non-neutral pronunciation (i.e. emphasis on a particular word) were excluded from the analysis. Measurements for word and pause duration were extracted using a script in Praat [20]. Statistical analysis was done using linear mixed model regressions in R, including random effects for participant, item and the number of phonemes in the word [21]. For each statistical comparison reported in the results, the overall effect of subject complexity was analyzed separately from object complexity, such that all object manipulations (O=1, O=2 and O=3) were included in the analysis of subject complexity, and vice versa.

3. Results

3.1. Word duration

Word duration was measured for the word preceding J1 (the verb) and the word preceding J2 (the last word of the subject). For J1 (verb duration) it was found that the duration of V was significantly greater when the subject was short (S=1) than when the subject was long (S=2: $t=-4.56$, $p<0.001$ or S=3: $t=-3.825$, $p<0.001$). The duration of V in S=2 compared to S=3 was not significant ($t=0.911$, $p=0.36$). The duration of V did not vary significantly with the length of the object (S=1 vs. S=2: $t=-0.647$, $p=0.5$; S1 vs. S3: $t=0.551$, $p=0.5$; S2 vs. S3: $t=1.182$, $p=0.2$). Figure 2 illustrates the mean duration of the verb in each condition.

For J2, it was found that the duration of the last word in the subject increased with the length of the subject (S=1 vs. S=2: $t=3.316$, $p<0.01$; S1 vs. S3: $t=5.633$, $p<0.01$; S=2 vs. S=3: $t=2.763$, $p<0.01$). Duration preceding J2 also increased significantly with the length of the object (O=1 vs. O=2: $t=3.48$, $p<0.01$; O=1 vs. O=3: $t=5.073$, $p<0.01$), although the difference between O=2 and O=3 was not significant ($t=1.57$, $p=0.117$). Figure 3 illustrates the mean duration of the last word in the subject for each condition.

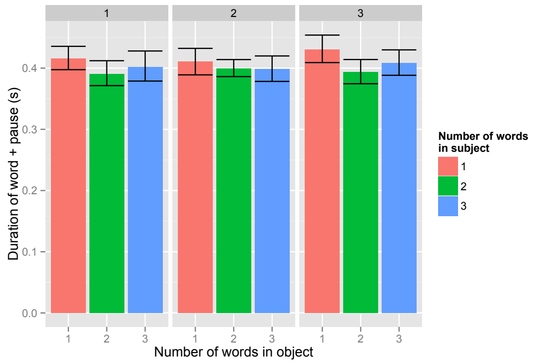

Figure 2: *Duration of verb at J1 by subject and object length.*

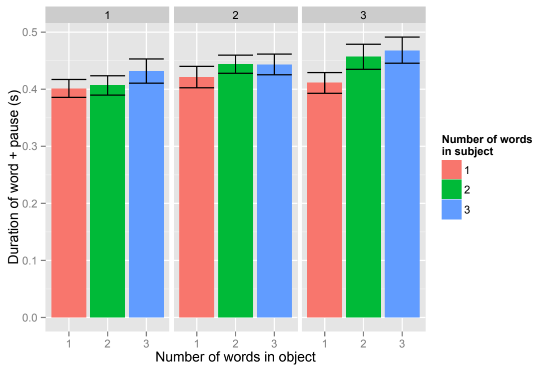

Figure 3: *Duration of word at J2 by subject and object length.*

3.2. Likelihood of pauses

Pauses were identified and measured at J1 (immediately following the verb) and at J2 (immediately following the last word of the subject. As shown in Table 4 and Table 5, it was found that pauses almost never occurred following J1 (n=5) and that the likelihood of a pause did not increase with the length of the subject or object.

Pauses are, however, much more frequent at J2. The likelihood of a prosodic pause increases with both the length of the subject (S=1 vs. S=3: t=4.056, $p<0.001$; S=2 vs. S=3: t=2.945, $p<0.01$) and the length of the object (O=1 vs. O=2: t=2.944, $p<0.01$; O=1 vs. O=2: t=5.125, $p<0.001$; O=2 vs. O=3: t=2.256, p=0.02). Only the comparison S=1 vs. S=2 did not emerge as significant (t=0.951, p=0.324).

Table 4. *Likelihood of pauses by subject length*

Subject Length	J1	J2
S=1 (n=246)	0.4%	28.5%
S=2 (n=236)	0.6%	32.6%
S=3 (n=233)	1%	43.8%

Table 5. *Likelihood of pauses by object length*

Object Length	J1	J2
O=1 (n=245)	1%	25.3%
O=2 (n=243)	0.5%	35.8%
O=3 (n=227)	0.4%	44.1%

3.3. Pause duration

As can be seen by examining Table 4 and Table 5, even at J2, the majority of sentences do not contain a prosodic pause. There is, however, a trend toward pauses of longer duration as the length of the subject increases (S=1 vs. S=2: t=2.834, $p<0.01$; S=1 vs. S=3: t=4.965, $p<0.001$; S=2 vs. S=3: t=1.852, p=0.06) and as the length of the object increases (O=1 vs. O=2: t=4.025, $p<0.001$; O=1 vs. O=3: t=6.548, $p<0.001$; O=2 vs. O=3: t=2.256, $p<0.05$). These results are illustrated in the boxplot in Figure 2.

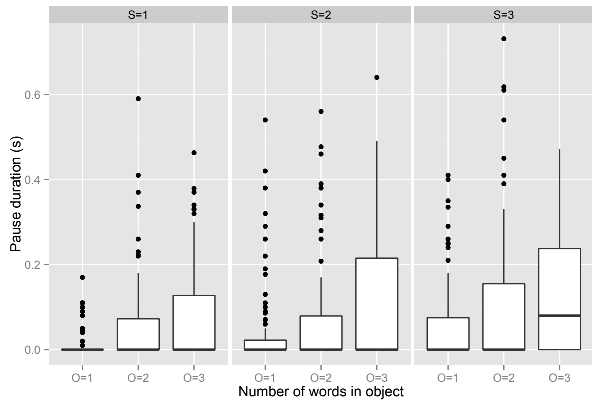

Figure 4: *Pause duration at J2 by subject and object length.*

3.4. Word duration plus pause duration

The combined measure of the duration of the word plus the duration of a following pause reinforces the observations made for J2. This value increases with the length of the subject (S=1 vs. S=2: t=4.339, $p<0.001$; S=1 vs. S=3: t=7.024, $p<0.001$; S=2 vs. S=3: t=2.783, $p<0.01$) and with the length of the object (O=1 vs. O=2: t=3.81, $p<0.001$; O=1 vs. O=3: t=6.814, $p<0.001$; O=2 vs. O=3: t=2.636, $p<0.01$). Figure 5 illustrates the results for duration plus pause at J2 by subject and object complexity.

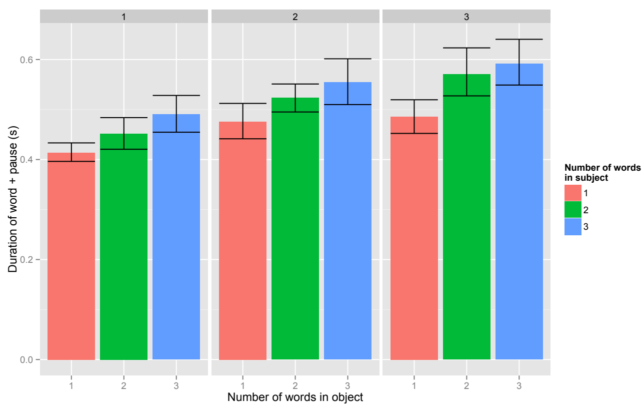

Figure 5: *Duration of word plus pause at J2 by subject and object complexity.*

4. Discussion and Conclusion

The results of the production experiment suggest that there is a marked difference in the relative strength of the prosodic boundaries at J1 and J2. There is almost no evidence for a prosodic boundary between the verb and the subject: the duration of the verb did not vary significantly between conditions and prosodic pauses were exceedingly rare.

There is, however, strong evidence of a prosodic boundary at J2. First, the duration of the last word in the subject varied across conditions, such that duration increased with the complexity of the subject and object, suggesting that the relative strength of the prosodic boundary depended on the size/complexity of the subject and object. Secondly, pauses were much more common at J2, again increasing in frequency and duration with increasing size/complexity of both the subject and the verb.

There are two main observations to explain. First, we need to account for the absence of the prosodic boundary at J1 and the robustness of the evidence for the prosodic boundary at J2. Secondly, we need to account for why the size/complexity of both subject and object affected the relative strength of the prosodic boundary at J2, but had no effect on the putative prosodic boundary at J1.

Regarding the first observation, I will propose here that an explanation can be found in the mapping from syntactic to prosodic structure. The basic syntactic structure for VSO sentences in Irish is [V[SO]] (for further details, see [5-8]). Crucially, S and O form a syntactic constituent to the exclusion of the verb.

Much recent work on the syntax-prosody interface has explored the relationship between hierarchical syntactic structure and evidence for recursion in prosodic representations. One hypothesis, formalized in Match Theory [4, 12] and implemented for Irish in [13, 14], is that syntactic constituents of certain types (word, phrase, clause) are in a correspondence relation with prosodic constituents of certain types (prosodic word, phonological phrase, intonational phrase). Relevant for the current analysis is the recursive prosodic representation of Irish VSO sentences argued for in [13, 14] on the basis of the distribution of phrasal pitch accents, and which mirrors the syntactic constituent structure. This recursive representation is derived by "matching" each syntactic XP in the syntactic structure with a phonological phrase φ (ignoring phonological null elements such as traces). Again simplifying the details, the syntactic structure [V[[DP_{Subj}][DP_{Obj}]]], which counts the subject and object constituents as phrasal DPs, would therefore map onto a prosodic representation (V((DP_{Subj})(DP_{Obj}))), where parentheses indicate the left and right edges of φ constituents. The prosodic representation mimics syntactic constituency because the subject and object constituents, while syntactic and prosodic constituents in their own right, also form syntactic and prosodic constituents together to the exclusion of the verb.

While this structure might initially lead one to the prediction that the verb should be prosodically separate from the subject/object constituent, [13, 14] presents evidence to suggest that the verb is parsed as a prosodic word rather than as a separate φ and thus is not separated from the subject by the right edge of a φ-level prosodic boundary. Returning to the experimental results discussed in the present paper, this would suggest that the absence of lengthening and prosodic pauses at J1 might also be explained by the absence of a right-edge φ-level boundary separating V and the following subject. Conversely, the presence of pre-boundary lengthening and prosodic pauses at J2 thus derives from the presence of the right-edge boundary induced by the right-edge of the DP constituent dominating the subject.

An alternative account relates to the observation that verbs and their dependent arguments are planned together and therefore unlikely to be separated by a prosodic boundary [18, 22]. While Irish appears to support the observation that the verb does not prefer to be parsed separately from its immediately following argument, the VSO word order found Irish adds complexity to this observation, as the dependent argument (the object) is not linearly adjacent to the verb and is separated from the VS complex by a prosodic boundary. Thus while it seems plausible that V and S are planned together in Irish, it is unclear how this fact can be accounted for under the hypothesis put forth in [18, 22].

The second main finding of the experiment was that, at J2, the relative strength of the prosodic boundary increased with the size/complexity of the subject and object constituents, as measured by the duration of the last word of the subject and the presence and duration of prosodic pauses. It has been observed in the psycholinguistic literature that the relative strength of prosodic boundaries seems to depend on the relative size/complexity of both recently uttered and upcoming material: increased complexity of recently uttered material increases the need for a "refractory period" and increased complexity of upcoming material increases the need for processing time to plan the production of the upcoming constituent [10, 15-18]. In Irish, assuming that the *location* of the prosodic boundary between subject and object is established based on syntax-prosody mapping principles as proposed above, it is expected that the *relative strength* of this boundary should vary depending on the complexity of the subject (resulting in an increased refractory period following the subject) and the complexity of the object (reflecting the increased processing time needed to plan the remainder of the utterance). Following this line of reasoning, the absence of the prosodic boundary following the verb at J1 may support the hypothesis that V and S are planned together, as we would otherwise expect that increasing the complexity of the subject would have an effect on the duration of the verb.

The implications of the model proposed here suggest a complex relationship between syntax-prosody mapping principles on the one hand, and processing and production planning on the other. Specifically, it was argued that the abstract structure of the sentence was responsible for determining the placement of the prosodic boundaries, but that the relative strength of these boundaries is a reflex of processing and production planning.

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