



# Investigating the Syntax-Discourse Interface in the Phonetic Implementation of Discourse Markers

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## Abstract

Discourse markers (DMs) are (chunks of) words stemming from the diachronic development of other parts-of-speech that tag the discourse's organization (ex. "well then", "innit"...). However, in synchrony, the formal accounts for the DM class vary from purely discourse-oriented definitions to models relying on a combination of lexico-grammatical and discursive information. We propose to bring new evidence into this debate by comparing the phonetic realizations of 4 DM types: stemming originally from adverbs, coordinators, subordinators and interjections. A discourse-only account would predict that the 4 types would be realized similarly, while a syntactic-discursive account predicts that subordinators would stand out, as they are less prone to syntactic independence. The analysis of various acoustic parameters (segment duration, F0, F1, F2 and HNR) in a finely-annotated 4-hour long corpus of French indicates that a hybrid approach may indeed be more accurate.

**Index Terms:** phonetics-pragmatics interface, syntax-discourse interface, discourse markers, French

## 1. Introduction

Discourse markers (henceforth DMs) are words or chunks of words such as "so", "well then", "innit", etc. that tag the discourse's organization, indicating relations between facts, ideas, discourse steps, or even the participants in the interaction [1]. While such a functional categorization of DMs is consensual among linguists, their formal categorization shows variation.

Some approaches consider DMs mainly from the point of view of their functional uses, whatever their form. Although they observe that DMs take their source in a variety of grammatical forms, such accounts do not take these different forms into further consideration when it comes to describing the DM class, considered as functionally distinct from other pragmatic categories (e.g., [2, 3, 4]). We will label such approaches as "discourse-only accounts".

On the other hand, there are more lexico-grammatical approaches considering explicitly the different morpho-syntactic classes to which DMs may belong and which may influence their use, because these different grammatical classes or parts of speech (henceforth PoS) show different forms of syntactic independence [5, 6]. Proponents of such a "syntax-inclusive approach" support that DMs rely on a combination of lexico-grammatical and discursive information [7, 8, 9], explicitly acknowledging that DMs come with a double affiliation, functional and grammatical.

In the present study, we propose to participate in this categorization debate from a new angle, i.e., by investigating the subphonemic cues available in continuous speech to disambiguate word meanings.

Past research has mostly investigated how phonetic cues can help disambiguate DMs' *pragmatic functions*, for instance between apologetic *vs* attention-seeking "sorry" [10]. Several studies on a wide variety of languages have shown that the DMs' pragmatic functions can be identified using a number of prosodic factors: intensity [10], in particular when combined with speech rate [11, 12, 13, 14], (local) speech rate or duration [10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20], pitch [11, 12, 13, 14, 15, 21, 22, 23, 24, 25, 26], pitch range [16, 17], and pitch reset [17, 18, 27], or stress in general [28], and presence and position of surrounding pauses [14, 18, 23, 25].

Fewer studies have investigated the DMs' PoS, and even fewer have investigated other acoustic cues than the ones related to prosody. Past research has shown that DMs and their non-DM homophones (e.g., *then* as a DM *vs* as a temporal adverb) vary in mean phone duration as well as formant values in French connected speech [29], thus confirming that DMs indeed constitute an independent class of words. In parallel, many studies have shown that syntactic functions can be disambiguated with phonetic cues. For instance, noun and verb uses of noun-verb homophones differ from one another in terms of word duration, vowel duration, pitch change, and vowel quality measures such as F1 and F2 in English child-directed speech [30]. In German read speech, homophone demonstrative pronouns, relative pronouns and definite articles also differ in duration, prominence and spectral characteristics [31], while the duration of the preceding silence as well as total, local and relative speaking rate, two F0 and two intensity related features, and the mean and median of F1 and F2 allow to disambiguate *ach*, *ah*, *auch*, *eine* and *er* reduced to [a] in Austrian German connected speech [32]. In French, homophone verbs and adjectives can be distinguished by prosodic features [33] and the comparison of lexical *est*, "is", and *a*, "has" with grammatical homophones *et*, "and" and *à*, "to" in connected speech shows that rising F0 and vowel duration allow to operate a reliable distinction [34].

We therefore build on the conclusion that PoS can be distinguished based on phonetic parameters to explore the discourse-only *vs* syntax-inclusive accounts of DMs. We hypothesize that, on the one hand, if DMs are purely discursive, they will display no phonetic differences based on the PoS of their non-DM homophones. On the other hand, if a syntactic-discursive view of the DM class is more accurate, acoustic differences should be found between DMs stemming from different PoS types. In the latter case, phonetic cues may also depend on the DMs' potential propensity to acquire syntactic independence with interjections and adverbs, and to a lesser extent coordinating conjunctions, being particularly prone to syntactic independence, while subordinating conjunctions display a stronger tendency to syntactic attachment [35].

To this end, we analyze 4 hours of French speech to com-

pare the phonetic patterns of one-word DMs as a function of their original part of speech, in particular fundamental frequency (F0), first formant (F1), second formant (F2), harmonic-to-noise ratio (HNR) and segment duration.

## 2. Data and Methodology

### 2.1. LOCAS-F

In this study, we use the data from the Louvain Corpus of Annotated Speech-French, a.k.a. LOCAS-F [36]. LOCAS-F contains 49 audio files across 67 speakers (31 women, 36 men) aged 18 to 86, for a total amount of 4 hours of European (mostly Belgian) French uttered between 2007 and 2017 in various contexts: broadcast news, homilies, political addresses, scientific conferences, informal conversations, etc.

This corpus is ideal for our preliminary study on the phonetic characteristics of DMs as it has been automatically enriched and manually corrected with many layers of linguistic annotation at the segmental level (phones, syllables), prosodic level (units, boundaries, contours, prominences), syntactic level (clauses, functional sequences, PoS), lexical level (tokens, words), and discursive levels such as fluency (filled and unfilled pauses, repetitions, false starts, substitutions) and discourse markers (pragmatic domains, semantic functions).

The part-of-speech of each item was automatically attributed using DisMo [37], which allows among other things to distinguish coordinating and subordinating conjunctions, which differ in term of syntactic independence, subordinating conjunctions being the most syntactically dependent PoS among DMs.

### 2.2. Methodology

For the present analysis, the acoustic values of F0, F1, F2, HNR and segment duration are automatically extracted at the phone level using a Praat [38] script adapted from [39]. Because some segments are too short, intensity could not be extracted. Moreover, due to technical issues, 2 scientific conferences (i.e., 2 speakers: 1 female, 1 male) are excluded.

We then select a subset of one-word DMs, to avoid interference from the prosody of larger chunks of words, especially clausal DMs (including a rected verb, e.g., “you see”). This operation results in a total number of 3,735 tokens.

The resulting data set is analyzed using R [40] to generate a conditional inference tree via Monte Carlo simulations including the following linguistic and phonetic factors<sup>1</sup>:

- variety of French: Belgian (BE), French (FR) or Swiss (CH),
- gender of the speaker: female (F) or male (M),
- speech style: informal or formal,
- duration of the segment (in seconds),
- mean F0 (in Hertz),
- mean F1 (in Hertz),
- mean F2 (in Hertz)
- mean HNR (in decibels).

The decision tree is expected to capture the hierarchical interaction between the variables when predicting different PoS types. The tree is generated by binary recursive partitioning [41]. The data is recursively partitioned into groups that are as homogeneous as possible. First, the model tests the null hypothesis of independence between the predictors and the response.

<sup>1</sup>Contrary to the indication that prominence could play a role in disambiguation in German [31], we do not include prominence in our own analysis because it would interfere with our five acoustic parameters.

The significance of the dependence is quantified by the p-value of a permutation test. The results are statistically significant if the proportion of the permutations providing a test statistically greater than or equal to the one observed in the original data is smaller than the significance level (i.e., 0.05). Then, the predictor with the strongest association with the response is used to split the data. This process is repeated until the data cannot be split any further.<sup>2</sup>

Finally, we also calculate the pairwise distance between the tokens from different groups of DM PoS. First, we generate a principal component analysis based on all the continuous variables (duration, mean F0, mean F1, mean F2, and mean HNR). The space consisting of the first two principal components (explaining 0.87 and 0.12 of the variance respectively) is then used to compute the pairwise distance between all tokens of a given PoS and all the tokens from another given PoS. For example, the distance between all the Adv (adverb) tokens and all the CC (coordinating conjunction) tokens is calculated. The distance between all pairs of PoS is then compared as a mean to visualize which PoS are closer to one another.

### 2.3. Data

In total, we have access to 3,735 one-word DMs across 41 DM-types. Among them, adverbials (Adv.) are the most represented and diversified, with 1,705 tokens across 25 word-types, while there are 1,402 coordinating conjunctions (CC) across 6 word-types, 432 subordinating conjunctions (SC) across 7 word-types and 199 interjections (Ij) across 5 word-types.

Since the word-types are different for each PoS category, phonemes are unequally distributed across the categories of our predictor variables, which biases the results, especially on the formant analysis. We thus limit the present analysis to phones that are represented in all 4 PoS categories: the vowel [a] and the voiceless stop [k], that are to be found in 548 DM-tokens across 18 DM-types. The 548 [a] (n=243) and [k] (n=305) phones are distributed as in Tab. 1. The data set with all [a] and [k] tokens as well as the R code used to analyze it are accessible at <https://osf.io/6hx2n/>.

label	Adv.	CC	Ij	SC	Total
a	136	5	45	57	243
k	150	5	44	106	305
<b>Total</b>	<b>286</b>	<b>10</b>	<b>89</b>	<b>163</b>	<b>548</b>

Table 1: Counts of [a] and [k] tokens in each part-of-speech category: adverbs (Adv.), coordinating conjunctions (CC), interjections (Ij) and subordinating conjunctions (SC).

## 3. Results

The mapping of the data on the F1/F2 vowel chart in Fig. 1 shows that the realizations of [a] and [k] in each PoS largely overlap. In particular, subordinating conjunctions seem to not particularly stand out, which would indicate that syntactic cohesiveness would not be a factor impacting the phonetic realization of DMs.

<sup>2</sup>We did not perform cross-validation since the algorithm already conducts a test of statistical significance at each split. For the same reason, pruning of the tree was not considered necessary.

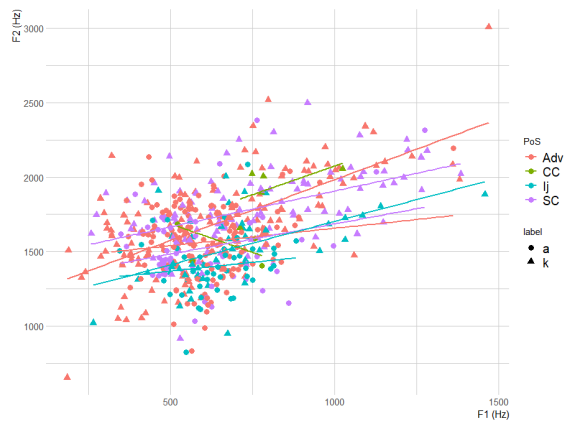


Figure 1: Vowel chart with F1 on the x-axis and F2 on the y-axis, forms of the pins indicate phone ([a] or [k]) and colors indicate PoS (Adv. = adverb, CC = coordinating conjunction, Ij = interjection, SC = subordinating conjunction).

The decision tree in Fig. 2 is read as follows. The variables considered helpful for distinguishing the DM PoS are shown in the tree, while the variables that are not considered significant are not. The decision process can be read by following the nodes. For example, if the duration is greater than 0.098 (Node 1 to Node 13) and if mean\_F2 is larger than 1547.469 (Node 13 to Node 17), there is a high probability that the DM PoS is an adverbial (Adv). In total, 59 tokens are annotated as Adv by this decision flow and the majority of these tokens are indeed adverbials. In general, the tree shows that segment duration, mean F2 and to a lesser extent mean HNR and speech style are relevant cues to categorize DMs as a function of their original PoS. The model's accuracy of 0.6095 compared to a no-information rate of 0.5219 ( $p < 0.0001$ ) indicates that, even though the decision tree can indeed distinguish the DM PoS, it is not performing extremely well. For example, the model generally misidentifies coordinating conjunctions, which is not surprising given the very small amount of data in this PoS category. It also shows that 62.9% of the interjections and 60.7% of the subordinating conjunctions are misidentified as adverbs. The poor performance of the algorithm may thus be due to an unbalanced count of data points in each PoS category, thus biasing the model in favor of the most represented one - adverbs. This suggests that the DM PoS are not easily distinguishable from one another based on the variables fed to the decision tree, which matches the conclusion from the visualization in Fig. 1.

These conclusions are further supported by a principal component analysis (PCA) and hierarchical clustering (Fig. 3). First, the visualization shows that tokens from different DM PoS largely overlap, i.e., they are not easily distinguishable from one another. Second, the output of clustering indicates that the ideal number of clusters to account for the present data is 3, although the number of PoS is 4 (Adv, CC, SC and Ij), which may be due to the very small amount of CC tokens (2% of the data). Furthermore, the suggested clusters do not match the DM PoS either, further supporting previous observations that different DM PoS are not easy to distinguish based on the considered variables.

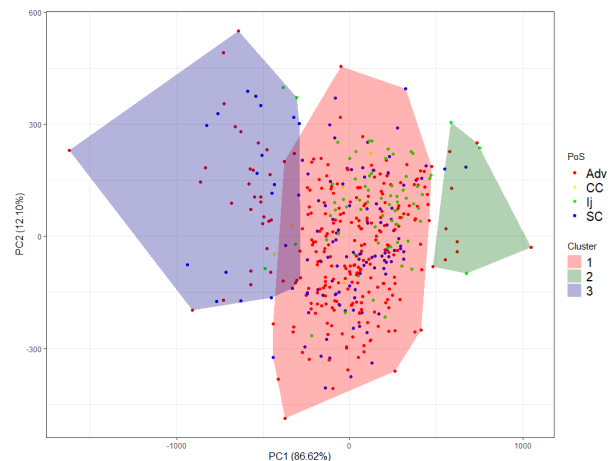


Figure 3: Cluster analysis for the subset of [a] and [k] phones resulting from a principal component analysis (PCA) and hierarchical clustering.

However, the pairwise-comparison displayed in Fig. 4 shows that the difference between the distances is significant for several pairs of PoS. In particular, the ADV/CC pair is significantly different from the ADV/IJ, ADV/SC and CC/IJ pairs, the ADV/IJ pair is also different from the SC/IJ pair, and the CC/IJ from the CC/SC. To summarise, this shows that CC is the closest to ADV, while SC and IJ are equally different from ADV. SC and ADV are equally close to CC, while IJ is more different from CC.

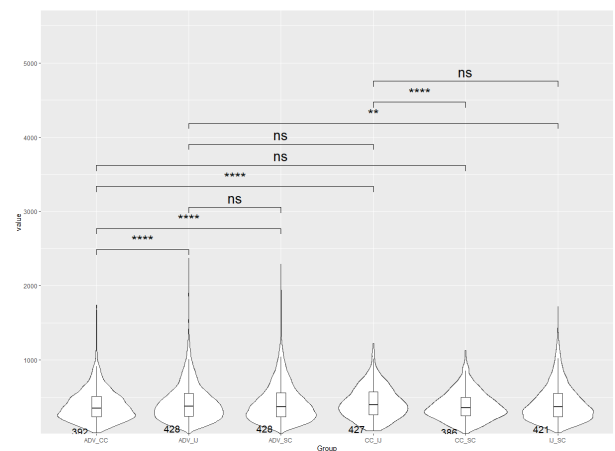


Figure 4: Pairwise distance for pairs of parts-of-speech: Adv = adverb, CC = coordinating conjunction, Ij = interjection, SC = subordinating conjunction. Significance: "ns" means "non-significant", \*\* means " $p \leq 0.01$ ", \*\*\*\* means " $\leq 0.0001$ ".

#### 4. Discussion and Conclusions

In the present study, we investigate two approaches for the definition of the linguistic class of discourse markers (DMs), i.e., a "discourse-only" account, which predicts that the DM class would be better accounted for from a syntactically independent view, vs a syntax-inclusive approach, which predicts that the part-of-speech (PoS) of the DM will impact its processing. We build on previous studies indicating that PoS can be identified using phonetic cues such as word and segment duration, pitch change, and F1 and F2 values to propose an analysis of DMs according to segment duration, mean F0, mean F1, mean

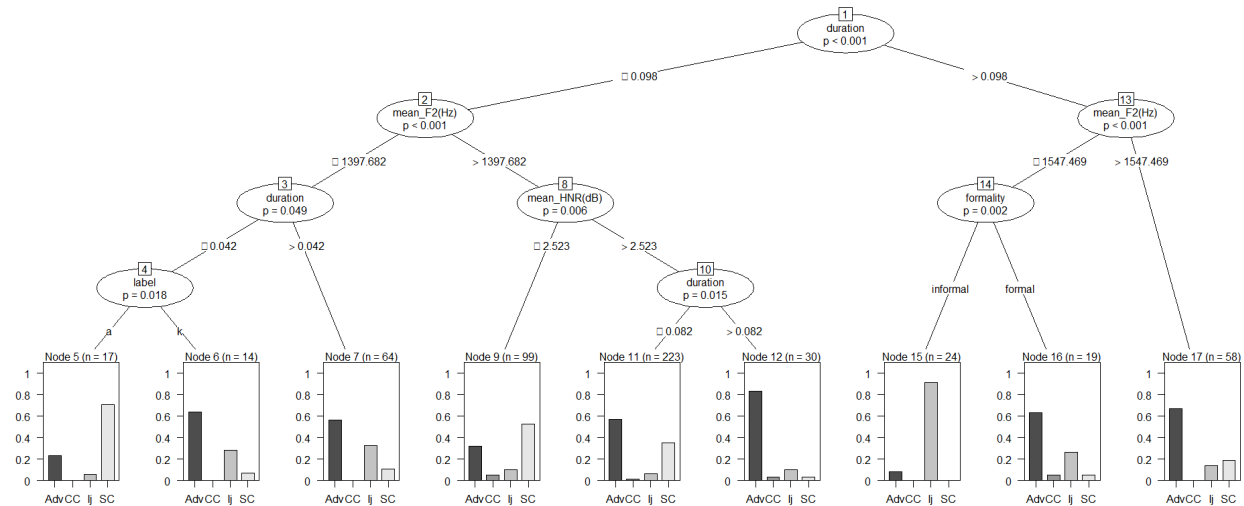


Figure 2: *Decision tree for the subset of [a] and [k] tokens. Predictor variable: part-of-speech (Adv = adverb, CC = coordinating conjunction, Ij = interjection, SC = subordinating conjunction); dependent variables: F0, F1, F2, HNR, segment duration, phone, variety of French, gender of the speaker and speech style.*

F2 and mean HNR. Results on 548 phones indicate that PoS can be moderately identified on the basis of subphonemic cues, thus advocating in favor of a syntax-inclusive account of DMs. Among the most useful cues, we show that segment duration and mean F2 play a greater role. However, the effect is rather weak, which may either be due to the small amount of data, or indicate that PoS is a weaker factor to distinguish DMs than non-DMs, thus confirming their hybrid grammatical and discursive identity. Moreover, we do not find that subordinating conjunctions particularly stand out phonetically, although they are expected to be less prone to syntactic independence. These results indicate that PoS correlates to a small extent with the phonetic realization of DMs, but that it is not a question of syntactic cohesiveness.

In future studies, we intend to remediate several limitations of the present paper. The first and most impacting one concerns the limited amount of data that we had at our disposal. Unfortunately, 4 hours of speech is not enough to draw strong conclusions on this particular issue, yet longer corpora including automatic and manual annotations of discourse markers and parts of speech are extremely difficult to develop. The second limitation concerns the position of the word in the clause, which has not been controlled for in our analysis. Yet, DMs, in French or any language, can be distributed differently in syntactic clauses according to their functions [6, 7, 42, 43], which may impact their phonetic realizations. In future work, we also intend to include an analysis of pitch slope, which has been shown to play a role in French [34], and to extract measures of F3 and F4, as well as center-of-gravity (CoG). Future studies should also propose an integrated approach of both segmental acoustics and prosody, and to investigate jointly DM PoS and DM pragmatic functions. Finally, we hope to be able to draw phonetic measurements on larger data sets, to extend our analyses to more phonemes, and ultimately to more languages, to test the generalizability of our findings.

## 5. Acknowledgements

This work was supported by an F.R.S.-FNRS research grant to Mathilde Hutin (project PPADisM).

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