Usage-based preferences in written sentence production: The role of local and global statistics

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Abstract

In this paper, we will discuss the role of different levels of frequency distributions in sentence processing and in written production, looking at French homophones. A comparison of experimental data and corpus statistics will demonstrate that lexical frequencies as well as local and global coherences have to be taken into account to fully explain the empirically established patterns.

Introduction

One of the central issues in research on human language processing concerns the factors influencing ambiguity resolution as well as the comprehension and production of complex sentences. Two general approaches are playing an important role here: (i) The specific architecture of the human language processing system is assumed to lead to predictable choices in cases of ambiguity resolution as well as to increased difficulty for certain constructions (Frazier & Fodor, 1980). Central to this approach are assumptions about architectural limits of the cognitive system such as limitations in working memory capacity (Gibson, 1998; Just & Carpenter, 1992; Lewis & Vasishth, 2005) or possibly executive functions (e.g. inhibition of irrelevant structures). (ii) Distributional properties, in particular the frequency of usage of certain constructions have been proposed to be a major factor more recently. In these approaches linguistic experience may interact with architectural constraints, or capacity-based explanations may even be replaced with ones based on experience alone (MacDonald & Christiansen, 2002).

Frequency effects may concern the lexical frequency of a word, or in cases of ambiguities, the relative frequencies of the respective meanings of the word, it may concern predictions derived from the preceding sentence context, which may include the full phrase marker constructed so far or only the immediately preceding word(s). These different levels of frequency information are currently under discussion in the sentence processing literature (e.g. Tabor, Juliano, & Tanenhaus, 1997, Tabor, Galantucci, & Richardson, 2004; Gibson, 2006; Konieczny, 2005). In this paper, we will discuss in how far hypotheses developed for sentence comprehension can explain sixth graders' spelling errors in French. We will thus investigate the influence of frequency effects on spelling errors on three levels: lexical frequency effects will be studied looking at syntactic category disambiguation for homophones compared to non-homophones, the global syntactic prediction will be based on the probability of a given category given the full preceding syntactic context, and the local syntactic prediction will be based on the immediately preceding word only.

Lexical category disambiguation seems to be strongly determined by the relative frequencies of usage of the respective category (MacDonald, 1993, 1994). Lexical frequencies, such as the frequencies of the verb's alternative argument structures, the frequency of the verb in active versus passive voice, and the frequency of the verb as a past tense versus as a past participle form play an important role in classical garden-path sentences like The horse raced past the barn fell, where raced is much more frequent as a past tense verb than as a past participle (MacDonald, Pearlmutter, & Seidenberg, 1994).

Upcoming syntactic structure can also be predicted by lexical frequencies of verbs. In a recent visual world eyetracking experiment on ditransitive constructions (1a,b) Tily, Hemforth, Arnon, Shuval, Snider and Wasow (2008), verbs occurring more often with double object constructions (such as teach) were compared with verbs occurring more often with a prepositional object (such as read) following the analyses provided by Bresnan Cueni, Nikitina, and Baayen (2007).

(1)   a. The lady will read / teach the children the poem.

        b. The lady will read / teach the poem to the chidren.

Participants were presented with sentences aurally while looking at quasi-scenes containing the objects referred to in the sentences. Eye-movements time-locked to the verb clearly reflected the anticipation of upcoming arguments compatible with the frequency of occurrence of the respective verb-frame (participants would prefer looking at the *poem* right after hearing *read*, while they preferred looking at the *children* right after hearing *teach*). The eye-movement patterns thus clearly suggest anticipation of syntactic structure based on the frequency of verb-frames.

    Global syntactic expectations have been shown to play a role as well. An example for context dependent preferences of syntactic category ambiguities can be found in Tabor, Juliano, and Tanenhaus (1997). In their experiments, they compared sentences like (2a,b) and (3a,b).

(2)   a. That cheap hotel was clean and comfortable to our surprise.

        b. That cheap hotels were clean and comfortable surprised us.

(3)   a. The lawyer insisted that cheap hotel was clean and comfortable.

        b. The lawyer insisted that cheap hotels were clean and comfortable.

    In a self-paced reading experiment, the determiner reading of "that" was easier to process in sentence initial position (shorter reading times on "hotel was clean"), whereas, postverbally, the complementizer reading was

easier (shorter reading times on "hotels were clean"). The dynamic model proposed by Tabor et al. (1997) to explain this pattern of results includes a context dependent component which is sensitive to the fact that the word *that* is more frequent as a determiner in the beginning of a sentence whereas the complement reading is more frequent after verbs taking sentential complements (such as *insisted*). Lexical category frequencies are thus calculated taking the syntactic context into account.

Whereas both readings of *that* are viable in the global syntactic contexts in the studies presented so far, more recent data suggest that the local syntactic context plays a role for syntactic category resolution as well, even in cases where the global context excludes one of the interpretations. Evidence for an interaction of lexical and local syntactic prediction effects comes from Tabor, Galantucci, & Richardson (2004) who found increased reading times for the ambiguous participle *tossed* in sentences like (4) compared to an unambiguous participle (*thrown*) although no main verb reading is possible at this point from a global perspective. Locally, however, the substring *the player tossed a Frisbee* forms a coherent sentence. Readers seem to be perturbed by this local interpretation.

(4) The coach smiled at *the player tossed a Frisbee* by the opposing team.

Similarly, in a visual world study with auditory presentation of the materials, Konieczny et al. (2009) find evidence for a temporary interpretation of the substring *die Astronautin überrascht den Ausserirdischen* (the astronaut surprises the alien) in a sentence like (5), although again this analysis is impossible given the global structure of the sentence. *Überrascht* is lexically ambiguous between an adverb (*surprisedly*) and a main verb (*surprises*) reading. Given that German sub-clauses require that the finite verb occur at the end of the clause, only the adverb reading is globally possible in a sentence like (5). Still, participants got distracted by the local substring compared to sentences with an unambiguous adverb such as *ungläubig* (*incredulously*).

(5) Die Tatsache, dass *die Astronautin überrascht den Außerirdischen* entdeckte, erregte Aufsehen.
The fact, that the astronaut[fem] surprisedly/surprises the alien discovered, caused a sensation.
"The fact that the astronaut suprisedly discovered the alien, caused a sensation."

Tabor et al. (2004) as well as Konieczny (2005, Konieczny et al., 2009) explain their respective results, claiming that the syntactic expectation of upcoming linguistic input is influenced not only by the syntactic context provided by the phrase structure of the sentence constructed so far, but

equally by local substrings constructed automatically in parallel irrespective of their global viability. Note that in both studies cited here, homophones (or homographs) are compared to non-homophones (or non-homographs) in contexts where one of the categories is only possible in the local context and excluded in the global context.

Gibson (2006) proposes an alternative to the dynamic model of Tabor et al. (1997, 2004), claiming that the patterns of results can often be explained by a combination of context independent lexical category frequencies (unigram bottom-up statistics) and syntactic top-down statistics. Gibson defines the lexical-bias (LB) for a syntactic category c_i as in (6).

(6) $LB(c_i)$ = (the context-independent probability of c_i (w)) * (the smoothed syntactic expectation weight for c_i in the syntactic environment).

A central factor in this formula is smoothing. Gibson argues that the probability of rare events is very hard to estimate given already that corpus studies can necessarily only cover a sample of all utterances. Moreover, language processing is very robust so that speakers often accept even fairly unusual constructions. The minimal probability of a syntactic expectation is arbitrarily set to .01. The relative syntactic expectation for a syntactic category c_i should thus be set to $p(c_i) + .01$, with $p(c_i)$ being estimated from a corpus.

With this minimal syntactic expectation, the high probability of the main verb reading of a verb like *tossed* in Tabor et al.'s experiments (or equally the high probability of the main verb reading of *überrascht* in Konieczny et al.'s experiments) will thus exert a certain influence even though only a past participle reading is possible in the global context of the sentence (or equally only the adverb reading is possible in Konieczny et al.'s experiments).

In a series of self-paced reading experiments, Gibson (2006) demonstrates that the high frequency of *that* as a complementizer results in increased reading times even in contexts only allowing for a determiner (7) compared to unambiguous determiners such as *those* or *this*, thus substantiating the relevance of context-independent lexical category frequencies.

(7) The lawyer for that skilled surgeon asked for a raise.

The increased processing load for *that* in the context of a preposition like *for* was similar to the processing load in a context with a verb that does not subcategorize for a sentential complement such as *visited* in (8), although it might be argued that the local prediction of a compementizer is generally increased in the context of a verb (Tabor et al., 2004).

(8) The lawyer visited that skilled surgeon.

Our central question in this paper is whether and in how far predictions originally stemming from sentence comprehension can be used to explain spelling errors. The lexical category ambiguities studied in the experiments presented so far, were all homographs and homophones at the same time. In French, due to its silent morphology, you consistently find homophones, which are ambiguous with respect to their syntactic categories whereas they are fully unambiguous in their written form. French thus allows us to have a very direct measure of syntactic category disambiguation just looking at orthographic error rates in writing.

The French language moreover allows us to vary homophones vs. non-homophones with and without local predictions (verb/noun homophones) and homophones vs. non-homophones with varying local and global predictions (adjective/verb homophone).

We will apply an adaptation of Gibson's formulae to experimental results from Pacton, Fayol, and Hemforth (in prep.), showing that we need at least a combination of global (sentence level) statistics and unigram (lexical) frequencies to explain agreement errors for French adjective/verb homophones and a combination of local statistics and unigram frequencies to explain agreement errors for verb/noun homophones. These results can be derived from corpus counts, showing that local predictions for verb/noun homophones are much stronger in the constructions under investigation than those for adjective/verb homophones. While the relative strength of local and global predictions seems to play an important role, only a combination of all three levels can finally explain the full pattern of results. Studying both types of homophones and thus both types of syntactic category ambiguities, finally allows us to give a more detailed picture of the processes under investigation.

Before presenting the experiments, we will describe the phenomena in more detail in the following section.

French adjective-verb and verb-noun homophones

In many languages, such as English, reference to the oral language is useful for morphological markers because the number differences are orally marked on the nouns (farm / farms) and on the verbs (chatter / chatters), and because adjective-noun agreement is marked in oral and written language. French spellers, however, often run into difficulties when using category specific plural markers because reference to the oral language is mostly impossible. Number markers for nouns ($\varnothing$ in the singular form vs. –s̲ in the plural form), adjectives ($\varnothing$ in the singular form vs. –s̲ in the plural form) and verbs ($\varnothing$ in the singular form vs. –n̲t̲ in the plural form) are not audible. Because of this

inaudibility, French conceals many homophones that are not homographs (i.e., words that are pronounced identically but are spelled differently). For example, the word *timbre* is written in the plural form with *–s* when it is a noun (*les timbres*, the stamps), with *–nt* when it is a verb (*ils timbrent*, they stamp); and these two plural forms, as well as the singular noun (*le timbre*, the stamp) and the singular verb (*il timbre*, he stamps) are all pronounced identically. Similarly, *bavarde* is written in the plural form with *–s* when it is an adjective (*les femmes bavardes*, the talkative woman, literally: the women talkative), with *–nt* when it is a verb (*les femmes bavardent*, the women chatter); and these two plural forms, as well as the singular adjective (*la femme bavarde*, the talkative woman) and the singular verb (*la femme bavarde*, the woman chatters) are pronounced identically. The silent inflectional morphology of French thus implies that writing a French word mostly involves decisions on its syntactic category that can only be inferred from an interaction of the word itself and its syntactic context. Systematic and extended explicit grammar lessons involving exercises in which children have to apply grammatical rules, in particular in second to fifth grades, do not prevent the occurrence of substitution errors (adding *–s* to a verb), especially for noun/verb homophones (e.g., *ils timbrent*, they stamp, spelled *ils timbres*) even in adults (Totereau, Thévenin & Fayol, 1997; Totereau, Barrouillet and Fayol; 1998).

Under standard writing conditions, most educated adults inflect nouns and verbs correctly, whether they have a homophone counterpart or not. Substitution errors only arise when adults' cognitive load is increased. In naturalistic situations, this can be observed when adults are more focused on the meaning of their message than on its orthographic correctness (e.g., university students' writing in exam situations). Experimentally, homophone effects can be demonstrated by using a dual-task paradigm aimed at elevating writers' cognitive load (Fayol, Hupet & Largy, 1999; Hupet, Fayol & Schelstraete, 1998; Largy, Fayol & Lemaire, 1996).

According to Totereau et al. (1998), although adults know the rule "if plural and verb then *–nt*" and how to apply this rule, they do not systematically perform the syntactical analysis in order to identify the syntactic category of the item to be marked. Rather, they retrieve from memory associations between stem and inflection (e.g., the association between *timbre* and *–s*) or whole instances (*timbres*). For a stem such as *trouve* (find) which can only be a verb, or *nuage* (cloud) which can only be a noun, whatever the syntactic structure in which they occur, the retrieval procedure and the application of the explicitly taught grammatical rules work towards the same response. However, for words, which can be either nouns or verbs, these two procedures can work towards different responses, because the writer can

retrieve from memory the nominal instead of the verbal form (e.g., *timbres* instead of *timbrent*) and vice-versa.

Totereau et al.'s interpretation of their data corresponds to an explanation based on lexical frequencies. However, in their experiments for adults in particular, words were embedded in syntactic contexts that may exert a specific influence as well. Writers may thus rely on their sensitivity to the fact that certain syntactic categories are more likely to occur in a given position than others without necessarily taking the global sentence structure into account. For instance, in a sentence like (9) writers could add –*nt* to the stem *bavard_* because they are sensitive to the fact that verbs often occur in a post-nominal position.

(9) Les femmes bavardent au coin de la rue.

The women are chatting on the corner of the street.

A local plural noun would thus demand for a verb with the plural ending -*nt*. Importantly, the succeeding syntactic context does not always confirm local predictions as in the previous example. For instance, in a sentence like (10), the third word is not a verb but the plural adjectival form of the adjective/verb homophone *bavarde*.

(10) Les femmes bavardes du village sont bruyantes.

The talkative women of the village are noisy.

In French, inflected adjectives do not only occur next to nouns but equally after copula verbs (e.g., forms of "être", to be). The key point here is that, while adjectives can occur in both positions (11), inflected verbs can occur in post-nominal position as in (9) but not after a finite copula verb.

(11) Les femmes bruyantes du village sont bavardes.

The noisy women of the village are talkative.

Thus, while writers' sensitivity to the fact that verbs frequently occur after nouns in French could lead them to inflect erroneously some adjectives with –*nt*, their sensitivity to the fact that verbs ending with –*nt* never follow a verb in French could prevent them from erroneously adding –*nt* to an adjective in these positions.

Sentences like (10) and (11) do, however, not only differ with respect to their locally preceding syntactic context. The adjective in (10) is also in the canonical position of the main verb in a typical French sentence. Thus, local as well as global syntactic predictions favor a verb as the current syntactic

category. This is not the case in a sentence like (12). Here, the homophone occurs in a post-nominal position, it is thus locally viable as a verb and not only as an adjective. Given that the preceding noun is the direct object of the sentence, the interpretation of the homophone as a verb is however excluded from a global perspective including the phrase structure of the whole sentence.

(12) Le boulanger regarde les femmes bavardes du village.

Lit.: The baker is watching the woman talkative of the village.

Finally, bottom-up lexical information may reduce or even exclude errors for adjectives without verb homophones as such as "bruyantes" in (11).

Similar predictions as for adjective/noun homophones can be derived from the verb/noun homophones discussed earlier. In a sentence like (13), locally as well as globally, *montre(-nt)* which is ambiguous between *la montre* (the watch) and *montrer* (to show) can only be interpreted as a plural marked verb. Adding *les*, which is ambiguous between the definitive article (the) and a clitic plural pronoun, before the verb changes the situation considerably (14). Given that *les* is much more frequent as a definite article than as a pronoun, locally, the substring *les montre (-s/-nt)* can be taken as determiner plus noun. Globally, however, this interpretation is not possible.

(13)   Il y a beaucoup de monde sous le chapiteau. Les magiciens <u>montrent</u> leur nouveau spectacle.

There is a big crowd under the circus dome. The magiciens show their new performance.

(14)   Quelques articles sont encore à vendre. Les marchands les <u>montrent</u> aux clients.

Lit.: Some goods are still for sale. The merchants them show to the clients.

As for adjective/noun homophones, bottom-up lexical biases may reduce or even annihilate local predictions for verbs without a noun homophone (e.g. *les marchands les exhibent aux clients*, the merchants exhibit them to the clients).

Pacton, Fayol, & Hemforth (in prep.) ran a series of experiments where they used a dictation task with 6th graders. The logic behind this choice was that 6th graders (about 11 to 12 years-old) generally master the fairly frequent kinds of syntactic constructions of relevance here, however, their orthographic post-editing skills are less developed than those of adults who only make a significant number of the expected mistakes under increased

cognitive load. The dictation task in French necessarily requires syntactic category resolution. It is moreover a task our participants are highly used to and therefore a fairly natural task tapping into the processes we are interested in.

In Pacton et al.'s study, the following pattern of errors was established:

- Homophones generally provoked more substitution errors than non-homophones

For adjective/verb ambiguities (*les femmes bavardes / bavardent*)

- Most substitution errors occurred in post-subject positions
- Post-copula-verb and post direct-object positions were highly comparable with respect to error rates (much lower than post-subject).

For verb/noun ambiguities (*Ils les montrent / les montres*)

- Substitution errors occurred mostly and very strongly following the word *les*

Corpus analyses and predictions

We used two databases to calculate syntactic predictions and lexical biases. For the syntactic predictions we used the French Treebank Corpus (Abeillé, Clément, & Toussenel, 2003). The corpus is based on 1 million words from the newspaper *Le Monde*, fully annotated and disambiguated for parts of speech, inflectional morphology, compounds and lemmas, and syntactic constituents. It is the only corpus parsed to the level we are interested in available in French. The constructions, we are looking at are highly frequent in French so that the use of an adult corpus seems justified. Still given the high frequency of the constructions, we only used a randomly chosen 13602-word subcorpus.

Since 6th graders language competence surely differs from that of adults with respect to vocabulary, we used the MANULEX (Lété, Sprenger-Charolles, & Colé, 2004) for lexical biases. MANULEX is based on a corpus of 1.9 million words extracted from 54 readers used in French primary schools between first and fifth grades. The database contains two lexicons: the word form lexicon (48886 entries) and the lemma lexicon (23812 entries).

Adjective/verb homophones

Table 1 shows the lexical, local, and global biases for verbs in the different conditions. Figure 1 shows expectancies based on lexical*local,

lexical*global, and lexical*local*global predictions Syntactic and lexical expectancies are smoothed (.01 is added to the corpus-based probabilities, contrary to Gibson, 2006, we also smoothed lexical biases using the same kind of reflection he proposes for syntactic biases).

		Lexical bias for verb (lemma)	Local bias for verb (compared to adjective)	Global bias for verb
Adjectives with verbal homophones	Post-nominal/subject	.51	.19	.46
	Post-verbal	.51	0	0
	Post-nominal/object	.51	.19	0
Adjectives without verbal homophones	Post-nominal/subject	0	.19	.46
	Post-verbal	0	0	0
	Post-nominal/object	0	.19	0

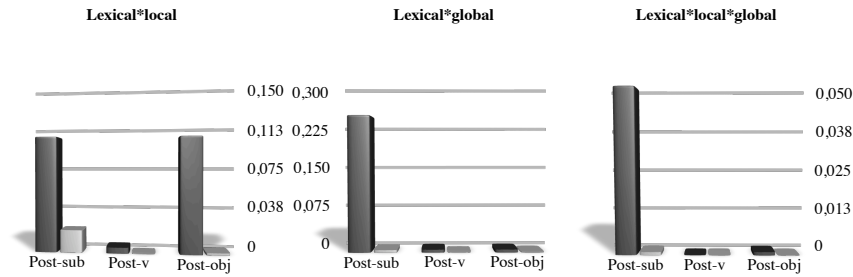Table 1: Statistics for adjective/noun homophones

Figure 1: Predictions of adjective/verb substitution errors

Only two of the three predictions correspond to the empirical data, where in particular adjective/verb homophones following the subject noun lead to a high number of substitution errors (verbal -nt instead of adjectival –s). Substitution errors can thus not be explained by local biases alone. A combination of lexical and global frequencies as well as a combination of lexical, local, and global frequencies, however, both predict the empirically established pattern.

Verb/noun homophones

Calculating the local bias is slightly more complicated for verb/noun homophones since the word *les* is ambiguous between a determiner and a clitic pronoun. In the *Le Monde* sub-corpus that we used for calculating syntactic predictions, *les* was a determiner in 97% of the cases. In 85% of these cases, a plural noun directly followed the determiner. The local bias can thus be estimated as .97*.85=.82.

Table 2 shows lexical, local, and global frequencies of nouns. Figure 2 shows the corresponding predictions of combinations of lexical * local, lexical * global bias, as well as lexical * local * global bias. Syntactic and lexical expectancies are smoothed (.01 is added to the corpus-based probabilities).

		Lexical bias for noun (lemma)	Local bias for noun (compared to verb)	Global bias for noun
Verbs with noun homophones	Post-subject	.48	0	0
	Post-les	.48	.82	0
Verbs without noun homophones	Post-subject	0	0	0
	Post-les	0	.82	0

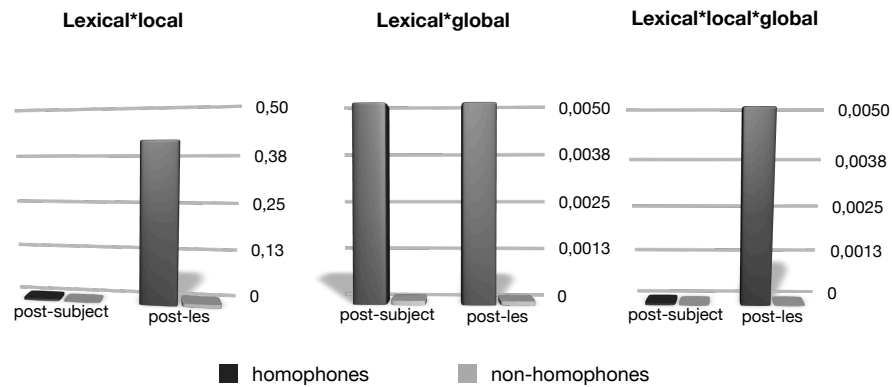Table 2: Statistics for verb/noun homophones

Figure 2: Predictions of verb/noun substitution errors

Neither lexical statistics alone, nor a combination of global and lexical statistics can explain the empirical data for verb/noun homophones, where a high number of substitution errors was found following the word *les* (nominal –s instead of verbal –nt). Only combinations of lexical statistics with local statistics (+ eventually global statistics) are compatible with the data.

Discussion

To explain the whole set of results we need a combination of bottom-up statistics (lexical frequencies), local top-down statistics (local coherence), and global top-down statistics. Predictions at different levels of the syntactic structure of the sentences are obviously underlying the disambiguation of syntactic category ambiguities in 6th graders.

Assuming that the spelling errors actually reflect comprehension errors (at least in part) in the dictation task, these results make clear predictions for sentence comprehension in general as well. They thus contribute to the discussion of which levels of analysis are relevant for the explanation of syntactic expectancy effects. Before these generalizations will be possible, we will, however, have to extend our empirical data base to direct comprehension tests and to adult populations.

References

Abeillé, A., L. Clément, and F. Toussenel. 2003. `Building a treebank for French', in A. Abeillé (ed) *Treebanks*, Kluwer, Dordrecht.

Boland, J. E., & Blodgett, A. 2001. Understanding the constraints on syntactic generation: Lexical bias and discourse congruency effects on eye movements. *Journal of Memory and Language, 45,* 391–411.

Bresnan, J., Cueni, A., Nikitina, T. and Baayen, R. H. 2007. Predicting the dative alternation,*in* G. Bouma, I. Kraemer and J. Zwarts (eds), *Cognitive Foundations of Interpretation*, Royal Netherlands Academy of Science, Amsterdam, pp. 69–94.

Fayol, M., Hupet, M., & Largy, P. 1999. The acquisition of subject-verb agreement in written French: From novices to experts' errors. *Reading and Writing, 11,* 153-174.

Frazier, L., & Fodor, J.D. 1980. Is the Human Sentence Parsing Mechanism an ATN?. *Cognition,* Volume 8, pp. 411-450.

Gibson, E. 2006. The interaction of top-down and bottom-up statistics in the resolution of syntactic category ambiguity. *Journal of Memory and Language,* 54, 363-388.

Hale, J. 2003. The information conveyed by words in sentences. *Journal of Psycholinguistic Research, 32,* 101–123.

Hupet, M., Fayol, M., & Schelstraete, M.A. 1998. Effects of semantic variables on the subject-verb agreement processes in writing. *British Journal of Psychology, 89,* 59-75.

Just, M. A., & Carpenter, P. A. 1992. A capacity theory of comprehension:Individual differences in working memory. *Psychological Review, 98,* 122–149.

Konieczny, L. 2000. Locality and parsing complexity. *Journal of Psycholinguistic Research, 29(6),* 627–645.

Konieczny, L. 2005. The psychological reality of local coherences in sentence processing. In *Proceedings of the 27th annual conference of the cognitive science society*.

Konieczny, L., Müller, D., Hachmann, W., Schwarzkopf, S., & Wolfer, S. 2009. Local syntactic coherence interpretation. Evidence from a visual world study. In *Proceedings of the 31st Annual Conference of the Cognitive Science Society*.

Largy, P., Fayol, M., & Lemaire, P. 1996. On confounding verb/noun inflections. A study of subject-verb agreement errors in French. *Language and Cognitive Processes, 11*, 217-255.

Lété, B., Sprenger-Charolles, L., & Colé, P. 2004. MANULEX: A grade-level lexical database from French elementary school readers. *Behavior Research Methods, 36*(1), 156-166.

Levy, R. 2008. Expectation-based syntactic comprehension. *Cognition* 106(3):1126-1177.

Lewis, R. L. & Vasishth, S. 2005. An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science, 29*, 375-419.

MacDonald, M. C. 1993. The interaction of lexical andsyntactic ambiguity. *Journal of Memory and Language, 32*, 692–715.

MacDonald, M. C. 1994. Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes, 9,* 157–201.

MacDonald, M.C. & Christiansen, M.H. 2002. Reassessing working memory: A comment on Just & Carpenter (1992) and Waters & Caplan (1996). *Psychological Review, 109*, 35-54.

MacDonald, M., Pearlmutter, N., & Seidenberg, M. 1994. The lexical nature of syntactic ambiguity resolution. *Psychological Review, 101*, 676–703.

Pacton S., Fayol, M., & Hemforth, B. in prep. Homophone Effects in Children's Spelling of Inflected Verb and Adjective Morphology.

Tabor, W., Galantucci, B., & Richardson, D. 2004. Effects of merely local syntactic coherence onsentence processing. *Journal of Memory and Language, 50(4)*, 355–370.

Tabor, W., Juliano, C., & Tanenhaus, M. K. 1997. Parsing in a dynamical system: An attractor-based account of the interaction of lexical and structural constraints in sentence processing. *Language and Cognitive Processes, 12*, 211–272.

Tily, H., Hemforth, B., Arnon, I., Shuval, N., Snider, N. & Wasow, T. 2008. Eye movements reflect comprehenders' knowledge of syntactic structure probability. *The 14th Annual Conference on Architectures and Mechanisms for Language Processing*, Cambridge, UK.

Totereau, C., Barrouillet, P., & Fayol, M. (1998). Overgeneralizations of number inflections in the learning of written French: The case of noun and verb. *British Journal of Developmental Psychology, 16*, 447-464.

Totereau, C., Thevenin, M. G., & Fayol, M. 1997. The development of the understanding of number morphology in written French. In Perfetti & A. Charles & L. Rieben (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 97-114). Mahwah, NJ, US: Lawrence Erlbaum Associates Inc.

Trueswell, J. C., Tanenhaus, M. K., & Kello, C. 1993. Verb- specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 528–553.