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Thesis

Investigation of the encoding processes involved in the production of French Adjective-noun Phrases: a psycholinguistic and linguistic approach

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Abstract

This thesis investigates the span of encoding in the production of French adjective-noun phrases (NPs). While speaking, speakers do not only articulate the portion of the sentence they have already encoded, they are also planning the rest of the sentence. The question then is what amount of planning scope is necessary to insure fluency in the production of a multiword utterance? This unit of encoding must be large enough to guaranty speech fluidity but small enough to prevent cognitive overload and speech outburst. Similarly, we investigate whether this amount of encoding varies and if it does, which constraints determine it. In a series of behavioural and ERP studies, we compare the production of one-word NPs to two-word NPs of two different syntactic structures (adjective+noun and noun+adjective). Our results show that the span of encoding is not constrained by syntactic structure and that the minimal unit of encoding varies across speakers.

Reference

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Investigation of the encoding processes involved in the production of French adjective-noun phrases:

a psycholinguistic and linguistic approach.

PhD Dissertation submitted in partial fulfilment of the requirements for the degree of Doctor in Linguistics

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Table of Contents

General Introduction

The aim of this thesis is to investigate the span of encoding in the production of French adjective-noun phrases (NPs) or how much is planned ahead before the initialization of the articulation. While speaking, speakers do not only articulate the portion of the sentence they have already encoded, they are also planning ahead the rest of the sentence. The question we address here is what amount of planning scope is necessary to insure fluency in the production of a multiword utterance. This unit of encoding must be indeed large enough to guaranty speech fluidity but small enough to prevent cognitive overload and speech outburst (Martin et al., 2010). Similarly, we address the question of whether this amount of encoding is a fixed unit or whether it varies. And if it does vary, which constraints determine this amount of encoding? It is a key question for the development of psycholinguistic models of speech production whose purpose is to describe how speakers do encode linguistic units and assemble them to produce continuous and coherent speech. The study of which linguistic units possibly determine the span of encoding during speech production might shed light on specific syntactic and phonological phenomena of the French language such as external sandhi. Moreover, a better knowledge of how much speakers plan ahead may help understanding some dysfluent patterns in aphasic patients with phonological impairment and possibly develop adequate intervention. Since the question of the span of encoding is relevant for different disciplines we will investigate this question in the light of the following fields: psycholinguistics including both behavioural and EEG data and linguistics.

This thesis will be divided as follows:

In the first chapter, we integrate a linguistic and psycholinguistic approach to the investigation of the span of phonological encoding, with a specific focus on adjective-noun phrases in French. Especially, we underline the fact that, even though adjective-noun phrases are short and simple units, they generate many questions from a linguistic and a psycholinguistic point of view. We therefore explore the possible implications of these issues before investigating the question of ahead planning of noun phrases with experimental paradigms.

In the second chapter, we review the different methodologies/approaches used to investigate the span of encoding in speech production in general. We then examine the literature concerning the investigation of the span of encoding and summarise the major results.

The following chapters all present a set of experiments based on different paradigms:

- *Chapter three* describes a set of behavioural experiments based on the manipulation of various variables in different picture naming tasks as well as reading tasks. In this chapter we first compare the production of one word versus two words. We then compare the production of two different types of adjective-noun phrases (with pre-nominal adjectives and post-nominal adjectives). Different linguistic observations underlined in Chapter one are integrated in the design of the experiments presented in this chapter.
- *Chapter four* presents a set of behavioural experiments based on a picture naming paradigm with auditory phonological distractors displayed at various SOAs. Based on the psycholinguistic review of the literature (Chapter 2), this second experimental chapter tries to account for the diverging results reported so far by suggesting that the span of encoding is modulated by inter-individual strategies.
- *Chapter five* reports two picture naming studies carried out under EEG recording with evoked potential (ERP) analysis. This chapter compares the production of one word versus two-word noun phrases and two different types of adjective-noun phrases. The experimental design is similar to Chapter 3 and 4 but this time, we integrate ERP analyses as well as a topographic analysis. This chapter allows to disentangle several methodological problems raised in the previous chapters and to go further with the previous results.

Eventually Chapter six integrates and discusses the implication of the results from these different approaches by taking into account the linguistic and psycholinguistic literature exposed in Chapter one and two.

Chapter 1: Psycholinguistic and linguistic accounts in the study of adjective-noun phrases in French

I.1 Introduction

In the late 1950s, the study of language as perceived by linguists was revolutionized by Chomsky's pioneering work on transformational grammar. Language was no longer described as a string of words but instead as a language-mind interface. This period marked the emergence of psycholinguistics as a discipline[1] of its own. New technologies (especially brain imaging and eye-tracking techniques) led to an independent methodological development of this field which moved more and more away from traditional linguistics. Precise models of speech production have since been established and are still the major references in the field. These models come from two different empirical traditions. Some models are based on the study of spontaneous and induced errors (Meringer & Mayer, 1895; Fromkin, 1973; Garrett, 1975, Dell, 1986) while other models are based on experimental data and especially mental chronometry [2] (Levelt et al., 1999). Even though they are based on different approaches, these models all agree on the different processes involved in speech production (see Figure 1 for a representation of the different encoding stages involved in speech production). Difficulties arise, however, when an attempt is made to describe the information flow between the different processing stages. While some models favor a strictly serial and discrete approach to speech production (Levelt, Roelofs & Meyer, 1999), others favor a connectionist and interactive approach (Dell, 1986). The purpose of this work is not to favor one or the other approach. However, as this work is mostly based on chronometric data and also because it is the most cited model, we will use Levelt et al., (1999) model as a recurrent reference.

According to Levelt (1989), when speakers produce speech, only one word is fully encoded before articulation of the message. Levelt´s hypothesis in particular and the question of how much is planned ahead in the production of several words in general has received increasing interest in psycholinguistics for the past three decades. This is the question we address in this work with a focus on the production of adjective-noun phrases in French. As the production of several words implies different linguistic units, we find it necessary to consider a linguistic approach when investigating how much speakers plan ahead before they speak.

[1] It is to note that psycholinguistics already existed long before the Chomskyan cognitive revolution since the first empirical studies date back to the end of the 18th century (see Levelt (2012) for a complete review of the history of psycholinguistics).
[2] Mental chronometry will be defined in the next chapter.

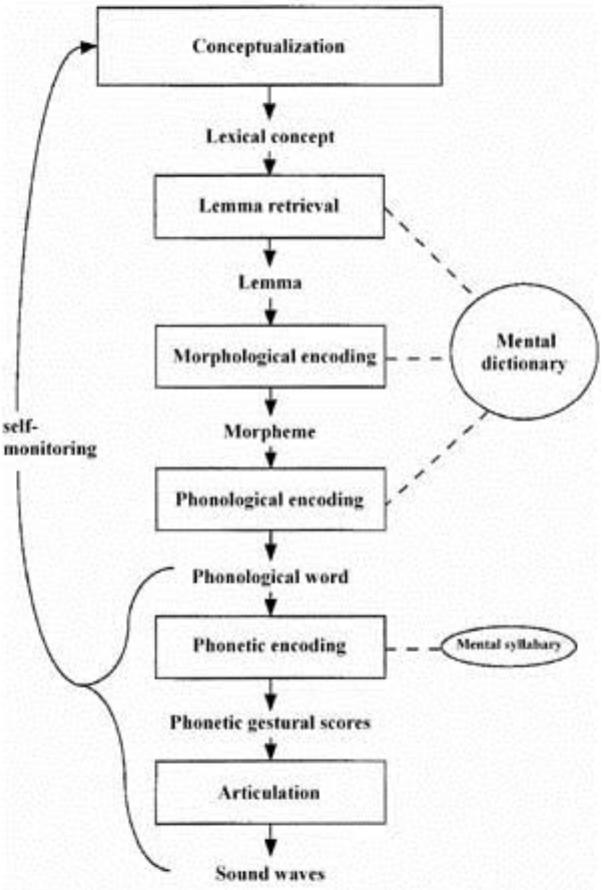

Figure 1. Representation of the different encoding stages involved in the production of one word (from Levelt, Roelofs & Meyer, 1999)

As we will see all along this work, psycholinguistics and linguistics share many areas of interest and the encoding of adjective-noun phrases is one of them. As French adjective-noun phrases can present different syntactic structures (with pre-nominal or post-nominal adjectives), we have to consider the possible linguistic implications of such a difference when investigating the span of encoding at the lexical-phonological stage. We will see that these different structures have implications at all the levels of encoding processes during speech production. It is therefore essential to be aware of these implications when interpreting the experimental results we report. This is why we will try to take into account both a linguistic and a psycholinguistic approach as far as possible. The main goal of this first theoretical chapter will be to examine the linguistic implications of the study of adjective-noun phrases in French in the light of psycholinguistic models of speech production.

I.2 The phonological word as the unit of encoding in psycholinguistic models of speech production

Psycholinguistic models of speech production tend to agree on the main levels of processing and representation involved in speech production. It seems fairly clear that production starts with an abstract concept which is transformed through semantic/syntactic and phonological encoding processes into an articulatory plan (Levelt, 1989; Levelt et al., 1999). This sequential encoding model has been largely used as a reference to investigate for the production of single words, mostly nouns and to a lesser extent for phrases and sentence production. Little is known about the planning processes involved in the production of several words. In particular, it is unclear how much of the message is encoded before one starts articulating and which linguistic unit determines the span of encoding at the different encoding levels.

A suggestion was proposed by Levelt (1989) in one of the most cited models of speech production. The author claims that "execution can follow phonological encoding at a very short distance […] this distance is probably the size of a phonological word (the smallest "chunk" delivered by the phonological encoder" p421)". For Levelt, a phonological word (hereafter PW) contains a lexical head and the different clitics[3] that depend on it; moreover, a PW in English should have only one accent. More generally, several psycholinguists seem to agree that a phonological word can be defined as a stressed word plus any unstressed word that attaches to it (Ferreira, 1993; Nespor & Vogel, 1986; Wheeldon & Lahiri, 1997). Speakers could therefore start articulating as soon as the first phonological word is encoded, independently of the complexity of the message to be produced. The reason why the *lexical word* is not suggested as the unit of encoding is because speech production models have to account for specific phonotactic phenomena, for example external sandhi (e.g. syntactic gemination[4] in Italian or *liaison*[5] in French). In these cases, the canonical phonological form of a word will differ when produced in a specific linguistic context. These phenomena clearly demonstrate that the production of a meaningful utterance cannot simply be the result of a chain of lexical elements converted into their phonological representations. According to Levelt (1989), phrasal boundaries will determine the segmental spellout for phonological

[3] Clitics are unstressed words, usually function words such as determiners, pronouns, preposition etc. (Riegel et al, 1994)

[4] The syntactic gemination (raddoppiamento sintattico) involves the lengthening of a word´s initial consonant after words of certain syntactic or phonological categories.

[5] The liaison in French involves the pronunciation of a latent word-final consonant when preceded by a vowel-initial word.

words; however, a major limitation of psycholinguistic models of speech production is that there is no general agreement on a detailed definition of the PW. The question of (1) planning ahead and (2) the nature of the linguistic unit of encoding gives rise to another question: (3) how is this linguistic unit determined and generated? If the question of planning ahead has received a lot of focus in psycholinguistics for the past thirty years, the other two questions have been seriously neglected. Except for a few studies (Ferreira, 1993; Wheeldon & Lahiri, 1997 and Shattuck-Hufnagel, 2000) which attempted to integrate these two questions into psycholinguistic models of speech production in the late 1990s, the question was soon buried in the benefit of other more general questions. On the other hand, much work has been accomplished by linguists in phonology over the past forty years and especially on the attempt to determine how a phonological unit is generated. This is probably where psycholinguistics and linguistics should meet.

I.3 The phonological word in linguistic models of phonology

If psycholinguists tend to oversimplify the nature of which linguistic unit delimits the span of encoding, linguists tend to do the opposite. While *phonological word* is employed by some authors (Selkirk, 1972; Hayes, 1989), others refer to *rhythmic word* (Pasdeloup, 1990) or *unit* (Di Cristo & Hirst, 1993), *prosodic word* (Vaissière, 1975), *accentual phrase* (Jun & Fougeron, 2000) or *group* (Verluyten, 1982; Martin, 1977) or even *phonological phrase* (Nespor & Vogel, 1986; Post, 2000). And this list is by no means exhaustive. As we can see, the very first issue among linguists is the terminology itself given to the PW. Even though little coherence seems to emerge from the variety of labels, two major theoretical accounts can be distinguished. One for which only the prosodic properties of the PW are taken into account, and one for which the grammatical properties are also considered. We will examine how the PW is accounted for in both groups.

I.3.1 The strictly prosodic approach

In the first theoretical account, Hall (1999) claims that the PW is a prosodic domain and that this unit is larger than the syllable and the foot but shorter than the phonological phrase. This definition is very general and meant to apply to all languages. But one of the main difficulties with the PW is that the criteria defining it vary from one language to another. In English for example, the PW can be defined as a unit bearing one main stress. It cannot be more than one stress nor less (Evans & Green, 2006). In French, authors suggest that a PW contains at least one syllable but a maximum of seven (Wioland, 1985; Riegel, Pellat & Rioul, 1994; Martin, 2009). Stressable syllables become necessarily stressed in order to prevent a succession of seven unstressed syllables; therefore, the PW in French can change depending on how the message is produced. If a speaker wants to stress part of his/her message, a specific syllable will be stressed and the PW might be different than if it had been produced in a neutral context. When applying these rules, one focuses strictly on the prosody of the message but ignores its grammatical properties. This is what defines the first group of researchers, namely a PW defined by a strictly prosodic approach (Hirst & Di Cristo, 1984; Jun & Fougeron, 2000).

I.3.2 The morpho-syntactic approach

In the second theoretical group, the morpho-syntactic properties of the message are taken into account when defining the PW (Selkirk, 1984, 2011; Nespor & Vogel, 1986; Delais-Roussarie, 1996, 2000; Mertens, 1993, 2008). Although this group agrees on the fact that morpho-syntactic features partly determine the borders of a PW, they do not all agree on how they operate and how much they regulate those processes. Many theoretical models of the interface between syntax and phonology have been proposed, and the purpose of our study is not to review all of them[6]; however, they can be classified into two major theories:

- The **Direct Reference Theory** according to which there exists a direct relationship between the phonological representations of words and their syntactic configurations (Kaisse, 1985; Rizzi & Savoia, 1993; Seidl, 2001).
- The **Indirect Reference Theory** (Nespor & Vogel 1986; Truckenbrodt, 1995) which on the contrary stipulates that this relationship between the phonological representations of words and their syntactic configurations is not necessarily direct and is instead mediated by phrasal prosodic constituents. This group includes models such as *the prosodic hierarchy* (Figure 2) originally proposed by Selkirk (1978, 1980, 1981).

[6] For a complete review of all the different theories of the syntax-phonology interface, see Elordieta (2008).

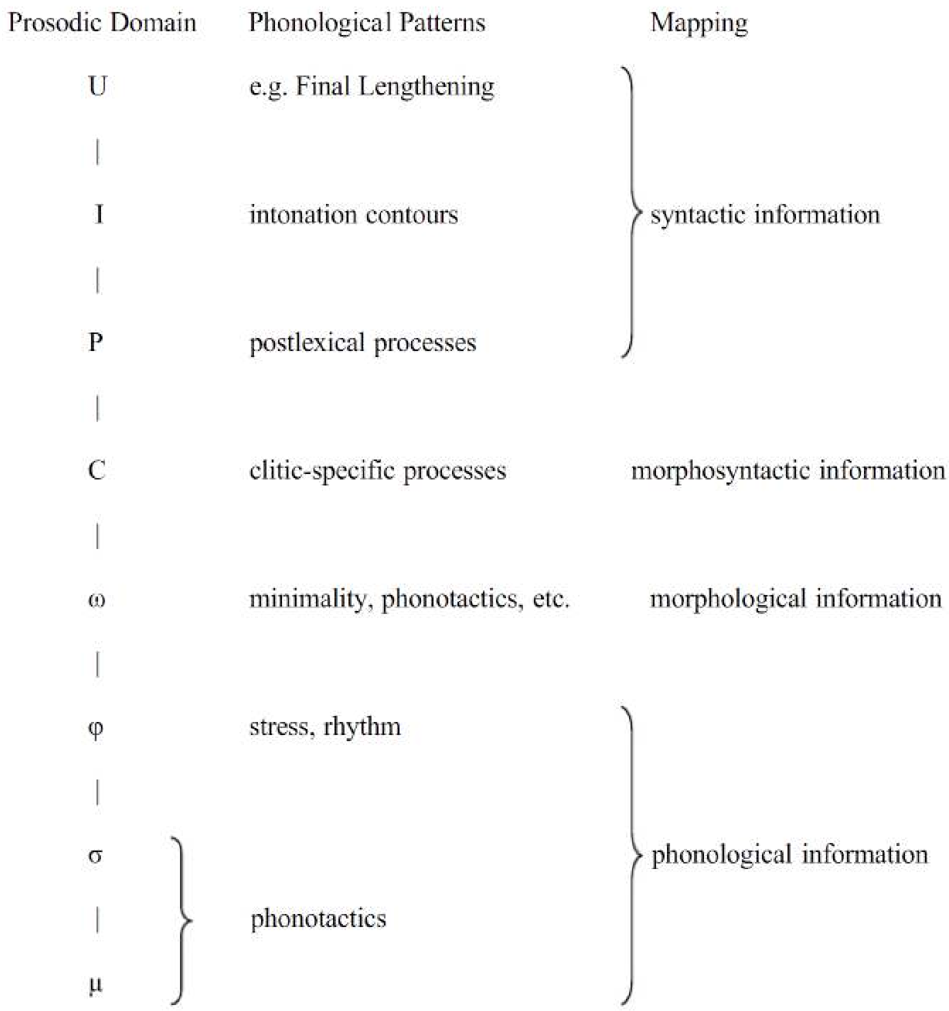

Figure 2. The prosodic hierarchy (Selkirk 1980, 1984; Nespor and Vogel 1986; Hayes 1989).

Figure 2 (taken from Schiering, Hildebrandt & Bickel, 2007) is an elaborate version of the original model which clearly illustrates the intermediary levels between syntactic and phonological information. The lowest constituents (the mora (μ), the syllable (σ), the foot (φ)) are defined strictly phonologically, while all the constituents above (the prosodic word (ω), the clitic group (C), the phonological phrase (P), the intonational phrase (I)) are defined morpho-syntactically.

To illustrate the indirect reference theory, see the example below, taken from one of the few psycholinguistics articles dealing with the question of the prosodic units in speech production (Wheeldon & Lahiri, 1997):

1. [[[**The man**]$_{NP}$ [[**I**]$_{NP}$ [[**talked to**]$_{V}$ [**in the school**]$_{PP}$]$_{VP}$]$_{S}$]$_{NP}$ [**is ill**]$_{VP}$]$_{S}$[7]
2. [[[[**The man**]$_{\omega}$ [**I talked to**]$_{\omega}$]$_{\phi}$ [[**in the school**]$_{\omega}$]$_{\phi}$]$_{IP}$ [[[**is ill**]$_{\omega}$]$_{\phi}$]$_{IP}$]$_{U}$

The first sentence represents the syntactic grouping of the sentence, while the second represents the prosodic structure. Even if the structure of the prosodic constituents (2) is strongly derived from the syntax of the sentence (1), a slight difference of grouping between the second NP and the verb demonstrates the two types of information are non-isomorphic but rather indirectly connected at some level. Whether one is in favour of the direct or indirect reference theory, none of the models proposed in the literature can clearly specify how the morpho-syntactic information relates to the generation of the prosodic structure precisely.

There has been a lot of debate between a strictly prosodic approach (I) and a morpho-syntactic approach (II) since the 1980s. More and more linguistic corpus based studies tend to agree on the latest approach (II). As for the few psycholinguistic studies investigating this question, experimental data tend to show that morpho-syntactic information does not intervene in the generation of the prosodic structure (Lahiri & Wheeldon, 2010). The question of whether phonological grouping is achieved in a syntactic fashion or a rhythmic one may remain unanswered, since all sentences can be grouped according to either fashion. What favors one approach or the other is speaking context, such as velocity, stress etc.; however, corpus based studies as well as psycholinguistics experiments cannot always take these parameters into account. The experimental tools available today may not be sufficient to simulate natural and spontaneous connected speech.

I.4 What are the implications for the investigation of encoding of French adjectival nouns phrases?

Instead of consensus, this short review of the psycholinguistic and linguistic literature on the PW only reveals the extent of the debate over which linguistic unit is the planning unit. Since this work will be based on the production of French adjectival NPs, we will now illustrate this issue with the example of the production of two different types of French adjectival NPs.

[7] NP= noun phrase ; V = verb ; VP= verbal phrase ; S= sentence.

Let us consider two examples taken from Di Cristo (2004):

(a) *La petite fille* (the little girl).

(b) *La fille charmante* (the charming girl).

I.4.1 The division of a noun phrase into phonological words

If a speaker has to produce (a) and (b), how much of this message will be planned ahead at the phonological encoding level? If we consider Levelt's serial model, the answer seems simple: one PW. But the question is then, how many PW are comprised in (a) and (b)? The answer is far from straightforward: while some (Nespor & Vogel) mean that (a) and (b) each constitute only one phonological phrase, others (Selkirk) mean that (a) is one phonological phrase and (b) comprises two phonological phrases, namely [la fille] and [charmante]. As we mentioned earlier, the PW in French can vary depending on the context (emphasis, velocity, stress etc.). If this is valid, it is a serious weakness to Levelt's model (and other psycholinguistics models which stipulate that the PW is the unit of encoding) since different speakers or speech contexts might lead to a different distribution of the PWs; therefore, we clearly have to be cautious when using the term PW when investigating the span of phonological encoding of French adjectival NPs. We will avoid the term PW for our study but rather use the term *encoding unit* at the phonological level; however, when reporting results from other studies using the term PW, we will use the same term.

I.5 Is encoding constrained by syntactic word order?

The question of word order is particularly relevant for us since French NPs can present two different syntactic orders: pre-nominal adjective-noun phrases and post-nominal adjective-noun phrases. It is therefore important to consider the potential implication of word order in the encoding process of NPs in French, as we cannot rule out syntactic encoding processes affecting processes occurring at a later stage (phonological-phonetic encoding).

I.5.1 Word order from a psycholinguistic point of view

From a psycholinguistic point of view, if one follows a serial and feed-forward model such as Levelt et al.´s, (1999) model, the planning of the production of an NP should undergo several processing stages. At first, the speaker´s message will be conveyed with no linguistic form (conceptual level). Then, during the second stage (the formulation stage), two main encoding processes will be involved:

1. A lexical (functional) level where the words (the lemmas) will be selected together with their syntactic properties (syntactic category, gender, syntactic role etc.). Their selection involves competition between lexical entries or lexical-semantic representations (Bock & Levelt, 1994).
2. A syntactic planning (positional) level where pre-stored phrasal frames will be attributed their constituents by the grammatical encoder. The constituents (lemmas) are organized together with their grammatical elements (determiners for example) in a linear and serial way. In the case of the production of a NP, general grammatical constraints such as *the adjective precedes the noun in an adjectival NP* apply at this level (this example is taken from Ferreira & Engelhardt (2006) and based on English).

However, in the case of French, where this particular grammatical constraint offers two possibilities (*the adjective precedes OR follows the noun in an adjectival NP*), external grammatical considerations (semantic or phonological) are taken into account by the system (Pinker & Birdsong, 1979).

The NPs presented in example (c) constitute an example of a phrase for which the semantic context will determine the position of the adjective: the two NPs will mean two very different things whether the adjective (A) is placed before or after the noun (N). In the pre-nominal position, the player plays a lot while in the post-nominal condition, the player is fat.

The following NP example (d) is a phrase for which the phonological context will determine the position of the adjective: *la grande porte* versus *la porte grande.* The sequence *la porte grande* generates a stress clash (two succeeding stressed syllables) between *porte* and *grande* which disappears when *porte* is placed first.

c. Un gros joueur / Un joueur gros (a big player)

d. La grande porte / La porte grande (the big door)

Once this processing stage is achieved, the phonological properties of the selected lemmas are retrieved (the lexemes) and assembled. In the final encoding stage preceding the articulation of the message, a phonetic (articulatory) plan is built on the basis of an abstract phonological code and the message can finally be articulated.

Based on experimental data (Schriefers, Meyer, & Levelt, 1990; Levelt et al., 1991; Jescheniak & Levelt, 1994; Jescheniak & Schriefers, 1998; Peterson & Savoy, 1998; Roelofs, 1992; Damian & Martin, 1999; Jescheniak, Schriefers, & Hantsch, 2001) this model (Levelt et al., 1999) was developed to account in particular for the production of single nouns. When it comes to the production of multi-word sentences this model raises several questions, including the question of word order, illustrated with examples (a) and (b) above.

1, The encoding of (b) is not problematic since it is a canonical structure in two ways:

- The N+A structure in French is considered the canonical structure[8] of an adjectival NP (Harris & Vincent, 1988; Riegel, Pellat & Rioul, 1994; Fox & Thuilier, 2012).
- Whether encoding occurs in a left to right fashion or is determined by the head of the phrase (here the noun), the order of the elements to be encoded will always be the noun followed by the adjective.

2, However, considering (a), which word is selected first at the lexical level?

- The noun because it is the lexical head of the phrase?
- Or the adjective because selection occurs in a left to right fashion?

It is therefore difficult to draw a conclusion of how the adjective in (a) is treated, especially whether it is selected before or after the noun. Two possibilities arise:

(1) If activation depends on the syntactic status of the elements of the NP, the noun should be selected first, then the adjective and eventually the determiner[9] at the lexical level. Then all these elements will be reorganized at the syntactic planning level. This suggestions leads to the hypothesis of an additional cognitive planning cost for the non-canonical structure such as (a) relative to a canonical structure such as (b).

(2) If activation depends on the position of the lexical elements, the adjectives should be selected first, then the nouns and eventually the determiner. No important reorganization should therefore occur during syntactic planning given this proposition, whatever the position of the adjective in the NP, since the elements are already encoded in the left to right fashion at the lexical level. In terms of cognitive cost, we

[8] The canonical order of French NPs will be developed in the following section.

[9] According to Garret, who based his model on speech errors, content words (nouns, adjectives, verbs, adverbs etc.) are selected before function words which have no semantic content. The determiner being a function word should therefore be selected after all the content words of the NP (adjective and noun) have been selected but before they have been planned syntactically.

can hypothesize that no difference should be observed between a non-canonical structure and a canonical structure.

There is a possible way to test these two opposite accounts and the predictions they lead to, in terms of planning cost with adjectival NPs in French: to compare structures such as (a) which might need to be reorganized at the syntactic planning level, to structures such as (b) which are already organized in a canonical way. Accordingly, if (1) is valid we should observe a difference between the planning cost for (a) and (b) since the non-canonical structure of (a) requires an additional reorganizing step at the syntactic planning level.

I.5.2 Word order from a generative (linguistic) point of view

Another way of addressing the question of word order is to consider theories of transformational-generative grammar.

Transformational-generative grammar is a linguistic theory mostly developed by Noam Chomsky. The specificity of this grammar is that sentences have two types of structure: a deep structure and a surface structure. In this framework, the rules which govern syntax (and therefore human language) are universal and innate. These universal (deep) structures are then transformed into surface structures. One of the features of transformational-generative grammar is syntactic movement. The basic idea behind syntactic movement is that to generate a non-canonical order and account for different word orders, the different elements can move from the canonical order or their (first-)merge position to some other (higher) position in the syntactic tree. It is important to note here that the canonical order of French NPs differs depending on the structure type. N+A is considered the canonical structure from a surface structure point of view while A+N is considered the canonical structure from a deep structure point of view. Universal grammar takes A+N as the universal structure. In that case, to generate a N+A NP, the noun has to move to a higher position than the adjective in a syntactic tree (Cinque, 1994; Abney, 1987; Ritter, 1991; Valois, 1991). This is called the head movement hypothesis and is illustrated by Figure 3. The generation of a N+A sequence is therefore more complex than the generation of an A+N sequence and should probably give rise to a cognitive cost relative to the canonical structure A+N (for an NP-movement analysis, see Cinque, 2005, 2010; Laenzlinger, 2005; Shlonsky, 2004).

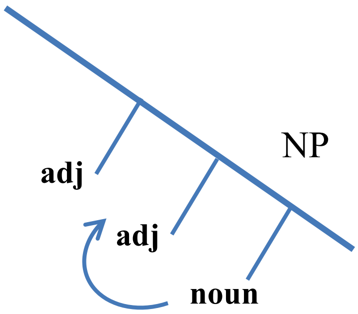

Figure 3. Illustration of the head movement hypothesis (Cinque, 1994) of a N+A noun phrase.

Two diverging predictions are therefore made by psycholinguistic and generative grammar theories when investigating the production of NPs in French.

Both approaches offer different predictions for the two types of structures (pre-nominal and post-nominal adjective NPs); however, there appears to be agreement on one point: unless one considers a strictly prosodic approach where prosodic components are blind to the syntactic content of the message, both theories seem to predict syntactic constraints on the encoding processes during production of adjective-noun phrases in French.

I.5.3 Word order constrained by speech performance

Another major account to determine how words are ordered in speech production is the theory of performance constraints by Hawkins (1994, 2000, 2001, and 2004). The theory of performance constraints stipulates word order is achieved in a specific fashion which aims to minimize processing demands both for speech production but also comprehension. This hypothesis was investigated both with psycholinguistic paradigms and linguistic corpus studies. This hypothesis will be discussed in the light of the results of Chapter 3.

I.6 The preferred order of the adjective

Along with the question of syntactic order is the question of the preferred position of the adjective within the NP. Several predictors can indeed determine the position of the adjective within the NP in French. These predictors were investigated in different corpus studies (see Thuilier, 2012 for the most recent study).

I.6.1 What predicts the preferred order of an adjective?

First, while post-nominal adjectives are more frequent in French (Thuillier, 2012; Forsgren, 1978; Wilmet, 1981), pre-nominal adjectives used to be the rule in ancient French (Glatigny, 1967; Wilmet, 1981; Bybee, 2009).

Second, different characteristics can be considered to predict the preferred position of the adjective within the NP. For example, if an adjective is phonologically shorter (fewer syllables) than a noun within an NP, it is likely to be pre-nominal (Forsgren, 1978). Frequency of the adjectives can also be a good predictor of the position of the adjective within an NP. Wilmet (1980) indeed observed that highly frequent adjectives tend to precede the noun in French adjective-noun phrases. Furthermore, Wilmet (1981) suggests a correlation between adjective frequency and the number of nouns it can be associated with: the more frequent the adjective, the more nouns it can be associated with. According to the author, a high rate of associations is more likely to occur for pre-nominal adjective-noun phrases (A+N). Additionally, semantic features of the adjectives can predict a specific preference. "Unbiased" adjectives for instance (colours, nationalities etc.) prefer a post-nominal position (Thuilier, 2012). Finally, the semantic relationship of the noun and the adjective within an NP has been described by some authors as being a good predictor of the position of the adjective (Waugh, 1977; Bouchard, 1998). The semantic relationship between an adjective and a noun is *tighter* when the adjective is pre-nominal while post-nominal adjectives are more *independent* from the noun they specify. To account for this phenomenon, (Bouchard, 1998, 2002) even proposes that A+N sequences form a single complex head. However, this claim has been criticized by others (Thuilier, 2012) and some counter-examples given. First, some NPs can have the adjective positioned first or after the noun without leading to any semantic difference as shown in (e). Moreover, semantic differences observed in an adjective-noun phrase in a specific position might not be observed in another adjective-noun phrase with the same adjective as shown in (f) from Thuilier, (2012). The semantic relationship between the noun and the adjective is not considered as a good predictor.

e. Une immense voiture / Une voiture immense (*a huge car*)

f. Un gros fumeur / Un fumeur gros (*a heavy smoker* / *a fat smoker*)
Un gros coiffeur / Un coiffeur gros (*a fat hairdresser*)

The list of factors constraining the position of the adjective within an NP in French we give here is not exhaustive (see Thuillier, 2012 for a review); however, it is sufficient for the purpose of the current study since we will only use a few different adjectives. Some of these predictors will be investigated in Chapter 3.

I.7 Conclusion

In this chapter we highlighted the different problems implicit in the investigation of encoding processes in the production of NPs in French. Even though French adjective-noun phrases are "short" and "simple" units (relative to longer more grammatically complex sentences), their syntactic structure is not arbitrary and presents implications at the different processing stages. The position of the adjective before or after the noun within the French NP can have implications at the semantic level (section I.6.1) but also at the phonological level (section I.4.1). The questions of which phonological unit determines the span of encoding, of the influence (or not) of syntax on phonology and of word order, are key questions for psycholinguistics as well as for linguistics. We did not find a clear answer to the definition of a possible minimal unit of encoding whether we considered a psycholinguistic approach or a linguistic approach. Some determining elements are lacking with both approaches, and the focus of this work will be to integrate the elements highlighted in this first chapter to the experimental chapters to come.

Chapter 2 will be a review of the literature on the span of encoding in speech production in general but with a general focus on the phonological encoding stage and NPs. In this review, we will try to keep in mind the implications raised in this chapter and see how the different studies on the subject deal with these issues.

Chapter 2: Different empirical methods to investigate ahead planning

II.1 Introduction

As we underlined in the preceding chapter, psycholinguistics is a multidisciplinary discipline which finds its roots in linguistics and psychology and sometimes also integrates neurolinguistic and neuroimaging methodological approaches. The very first methodology of psychology of language was based on observation, in particular based on the description of speech errors; then experimental paradigms stemming from cognitive psychology became widely popular and since the nineties they are often integrated with brain imaging techniques. In this chapter we will review the methods based on observation and experimentation employed in psycholinguistics to investigate the question of the span of encoding. We will present the various advantages of these methods but also their limits. Functional brain imaging (evoked potentials) approaches to the investigation of the span of encoding will be developed in Chapter 5.

II.2 The study of speech errors

Several methods have been used to investigate the question of how much is encoded before articulation in speech production. The earliest source of information concerning the extent of advance planning in language production was the study of speech errors (see Fromkin, 1973; Garrett, 1975, 1980; Meyer, 1992). Speech errors can indeed be very informative. Errors occurring at the lexical level, word exchanges, for example, are typically always words from the same grammatical category. For instance, in the example "*Wash your fruit before you eat your hand*" the noun is exchanged with another noun but not a verb. The error affects the place of the word but not its form. From this example, we can observe that at the stage of grammatical encoding, all the lexical items constituting the noun phrases were already activated but they switched their position in the sentence. This phenomenon is one of the main clues to the distinction and separation between the lexical and the phonological level. Indeed, we observe the opposite phenomenon with errors at the phonological encoding levels. In the example: "*The nipper is zarrow*" (from Fromkin, 1971), the syntax is correct but the onsets of the words have been exchanged. Only the phonological properties of the words and not their syntax were affected.

Moreover, exchange of phonemes can occur within different grammatical categories. In the previous example, the onset of a noun had been exchanged with the onset of an adjective which hardly happens with errors occurring at the lexical level. The study of speech errors demonstrates that these errors are seldom arbitrary and fall into distinct categories depending on the level of encoding affected. These arguments are in favour of the distinction between a lexical level where words are selected and their syntactic organization is achieved and a phonological encoding level where word forms are determined. But what is interesting for us is the span within which these errors can occur. Errors at the lexical level can occur in a fairly large span while the span for errors at the phonological encoding level seems to be much smaller (Rossi & Peter-Defare, 1998). However, even if some researchers based their model on the observation of errors (Dell, 1986; Dell & O'Seaghdha, 1992) one should be careful about using errors as a way to determine what processes are involved in "error-free" speech production. The only reliable piece of information one can derive from the study of errors is that the span of encoding is probably shorter at the phonological level than at the lexical level.

The observation of errors in speech production to investigate the span of lexical-semantic encoding has been recently studied by Gillespie and Pearlmutter (2011). The authors analysed syntactic agreement errors to investigate advance planning in grammatical encoding in sentence production. The authors made the hypothesis that individuals' difference in speed of speech production and planning scope might influence their sensitivity to agreements errors. They investigated this hypothesis by measuring speech onset latencies and error agreement in a picture description task involving complex noun phrases. Results showed that speakers who were slower to initiate speech produced more agreement errors, suggesting that slower speakers do more advance planning and are more likely to experience interference during agreement computation probably due to an overload of the encoding system. This proposal will be investigated in Chapter 4.

II.3 The picture naming task as an experimental paradigm to investigate the span of encoding

II.3.1 Picture naming paradigms

Experimental paradigms offer several methods to test the span of encoding. One crucial issue in the study of speech production is the control of the message speakers are going to produce (see Bock (1996) for a review on methods and methodologies employed to study speech production). One common method psycholinguists have adopted to have participants produce an expected sentence is to display a specific picture on a screen and have participants name this picture. This method is called the picture naming paradigm. In a picture naming task, participants are usually asked to name these pictures as fast and as accurately as possible. The time it takes the participant from the onset of the picture until they initiate their response is the independent measure of this task. The resulting production latencies (or reaction time, RT) is an indicator of the time course of speech processing (mental chronometry). An example of a condition in this paradigm can be viewed in Figure 4. Changes in production latencies linked to specific experimental manipulation are used to infer about the processing cost induced by the manipulation. When investigating ahead planning, longer naming latencies might reflect a larger span of encoding. Several parameters (see following section) can be associated or manipulated to investigate the span of encoding at the different processing levels. Here we will review several studies based on picture naming paradigms and the manipulation of specific variables in order to investigate the span of encoding.

Figure 4. Example of a picture naming paradigm where participants are expected to produce the noun-phrase *the big duck*.

While picture naming is a convenient task to elicit conceptually directed speech, it is still very limited when it comes to the production of multi-word sentences. It is indeed difficult to elicit pictures which are too not visually complex and for which all participants agree on what to name. An example of the limitations of this method will be highlighted in Chapter 5 as we will see that different visual stimuli employed to elicit similar adjective-noun phrases can actually generate different visual encoding processes which cannot be revealed with a simple behavioural study.

II.3.2 Reading tasks

An alternative method to avoid constraints relative to a naming paradigm is to use a reading task. Reading tasks allow more control of speech production but they also present some limitations. We will first describe the hypothetical processes involved in reading aloud and then discuss the limitations of this paradigm.

From print to speech, several processes are involved. These processes are partly shared with naming processes. However, the major distinction is that there are different processing routes when converting print to speech. According to the most cited model of reading aloud (Dual Route Cascading model (DRC) model from Coltheart, Rastle, Perry, Langdon and Ziegler, 2001), there are three different paths when processing a written word into speech (see Figure 5). One route is a lexical route (1 on Figure 5) which is used for the processing of known words. This route activates two lexicons: an orthographic input lexicon, where the letters of the target word are perceived and associated with the word it corresponds to in the mental lexicon and a phonological output lexicon where the phonology of the target word is retrieved. This lexical route can activate a semantic system (the lexical semantic route: 1,a on Figure 5) or not (the lexical non-semantic route: 1,b on Figure 5). The third route (non-lexical: 2 on Figure 5) is a grapheme to phoneme conversion (GPC) which is assumed to be used for reading non-words. Each grapheme is assigned to the most frequent corresponding phoneme and the conversion occurs serially (from left to right) letter by letter. All the units (lexical and phonological) of the system are interconnected via inhibitory or excitatory connections. The connection between the lexical and phonological lexicon are excitatory only.

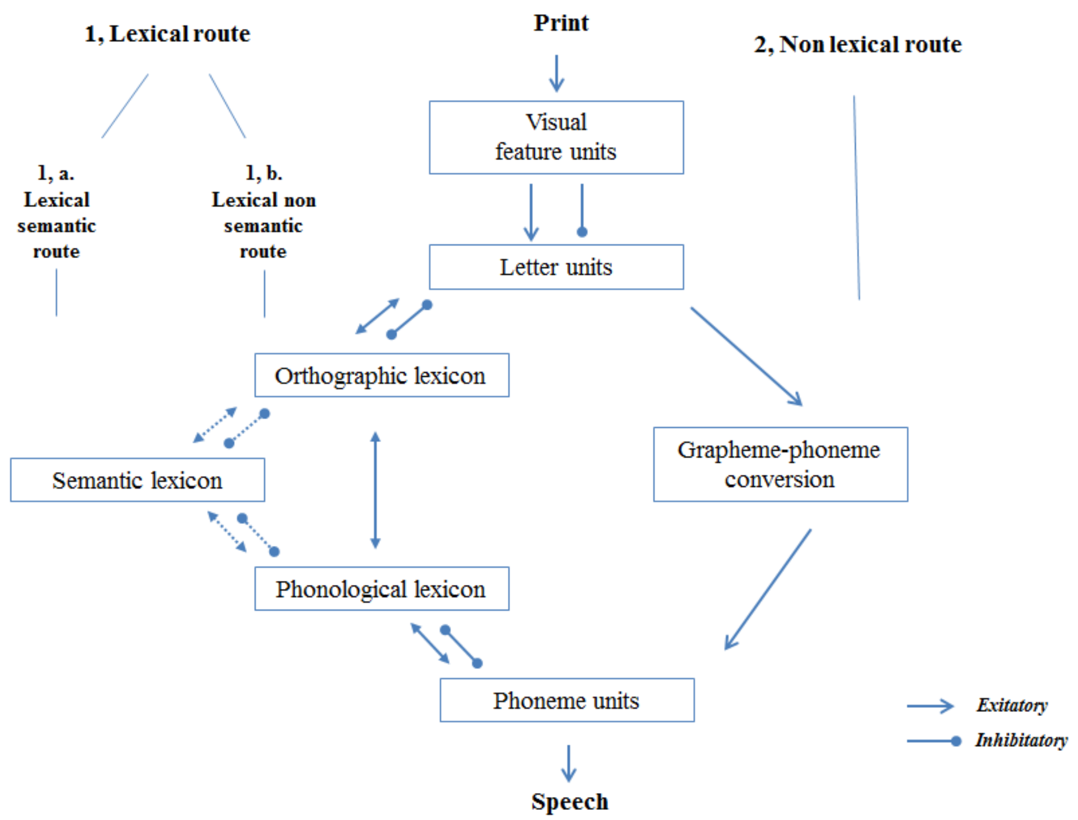

Figure 5. Representation of the DRC model by Coltheart et al., (2001).

The very first difference observed between the results obtained with a reading and a naming task is that naming latencies are shorter for the reading task relative to the naming task (Cattell, 1885; Ferrand, 1999). Several hypotheses have been suggested to account for this difference. Cattell (1885) suggested that this difference was due to the fact that reading was a frequent practice as people read on a daily basis. Therefore the association of a written word and its pronunciation is automatic. Naming a picture, on the other hand, requires a voluntary effort and is a controlled cognitive process. This is called the "differential-practice hypothesis". A following assumption is that learning to practice naming pictures should reduce naming latencies to similar reading task naming latencies. This was tested by several studies (Brown, 1915; Lund, 1927; Ligon, 1932; Fraisse, 1969) but even though naming latencies for naming pictures decreased consistently, the difference between the two tasks always remained. Fraisse (1969) suggested an alternative hypothesis to account for this difference, namely the "uncertainty hypothesis". According to this author, reading a word only leads to one possible response. Naming a picture, however, might generate several responses (e.g. the picture of a *pigeon* could also lead to the response *bird*). The time it takes to decide which word corresponds to the picture would account for the longer naming latencies in a PNT. This hypothesis was tested by Gholson and Hohle (1968) who compared reading of words and naming pictures for which the number of alternatives varied. Differences decreased when the number of possible alternatives went from six to four and disappeared when the picture could only generate two responses. The last major hypothesis (so-called "semantic hypothesis") is that when reading a word, the system does not need to access the semantic lexicon to spell out the word correctly while in a naming task, the system has to activate the semantic representation of the word to produce it (Theios & Amrhein, 1989). The difference in reaction times would therefore come from this additional semantic stage in the PNT. Similarly, if reading a word is operated by the non-lexical route, fewer stages will be necessary for reading a word relative to naming a picture.

However, reading and naming tasks are not entirely divergent. These two tasks are also thought to share similar encoding processes. Both models of reading (DRC) and models of naming (WEAVER ++ which is a thorough model of lemma retrieval proposed by Roelofs, 1997) predict segmental spellout for words and serial prosodification. Roelofs (2004) predicted that because similar processes were proposed in both models, this suggested that these processes were shared in both tasks. He indeed reported similar seriality effects for both reading and naming tasks concluding that serial phonological encoding processes was shared between naming and reading the name of an object.

In sum, even though reading tasks are an efficient method to elicit speech, it is difficult to make sure that all the stages involved in speech production are processed in such a task and the comparison with a PNT is fairly limited. PNT probably shares more stages with spontaneous speech production but reading and naming seem to involve similar phonological planning processes. This theorie will be further discussed in the following chapter as we will compare the production of three different NPs across naming and reading tasks.

II.3.3 The manipulation of linguistic variables

Several linguistic properties of the target words are known to affect naming latencies (and therefore processing times) in a picture naming task. For example, lexical frequency[10] (Oldfield & Wingfield, 1965) and the age of acquisition (AoA) of the word to be named (Barry, Morrison & Ellis, 1997) are reported to be major predictors of naming latencies. Participants performing a picture naming task in which the frequency or AoA of the target stimuli have been manipulated will obtain shorter naming latencies for high frequency words

[10] Lexical frequency and Age of Acquisition (AoA) of a word are two variables often used in psycholinguistics as their effect is quite robust (especially AoA).

or early acquired words and longer naming latencies for low frequency words or late acquired words.

Alario, Costa and Caramazza (2002) used frequency effects with noun phrases (NPs), e.g *the blue kite* in English to investigate the span of encoding. They manipulated the frequency of the nouns and of the adjectives and calculated participants' reaction times in a picture naming task. They observed frequency effects for both the noun and the adjective concluding that the entire NP was encoded at a level of encoding which they determined was the phonological level. Schnur (2011) also used the frequency effect in complex sentences such as "*she catches the fly*". The frequency of the noun was manipulated. Schnur reached a similar conclusion, namely that the entire phrase was encoded. However, as Alario, Costa and Caramazza (2002) underline in their study, the locus of the frequency effect and of AOA in picture naming is still debated. These variables can indeed be strongly correlated with others such as "name agreement", "familiarity" etc. Therefore, the manipulation of these variables might not reflect what happens at the phonological level but at the lexical-semantic level.

II.3.4 Determiner selection as an estimate of the span of encoding.

Another way of exploring the span of phonological encoding is to use a paradigm based on determiner selection as Spalek, Bock and Schriefers (2010) did. They showed that the phonological properties of the phrase-final noun affected the production of the phrase-initial determiner (e.g, RTs were slower for NPs whose underlying and produced determiners were different than for those for which it was the same determiner). For example, in the sequence *a purple giraffe*, the addition of the adjective does not affect the choice of the determiner, i.e. *a giraffe* and *a purple giraffe*. However, in the sequence *a purple elephant*, the addition of the adjective changes the choice of the determiner of the noun into *a* instead of *an, i.e. an elephant* but *a purple elephant.* The authors obtained slower naming latencies when the phrase-initial determiner differed from the determiner required by the noun in isolation than when the phrase-initial determiner matched the isolated-noun determiner. They interpreted these results as evidence that phonological encoding had been completed up to the noun of the sequence before articulation. This paradigm was also tested with another romance language, namely Italian in a study by Miozzo and Caramazza (1999). Participants were asked to produce adjectival NPs such as *il grande tavolo* (the big table) or *il grande sgabello* (the big stool). In Italian adjectival NPs, the form of the masculine definite determiner can vary depending on the context of the utterance. While *il tavolo* (the table) is produced as both as *il tavolo* in a simple NP and as *il grande tavolo* when produced as an adjectival NP, *lo sgabello* (the stool) will have a different determiner selected while being produced in an adjectival NP *il grande sgabello* (the big stool). The authors reported longer RTs for the second condition where phonology of the noun and its determiner was inconsistent (in Experiment 5 only). The fact that incongruent phonology of the noun as the latest element of these Italian NPs affected naming latencies suggests that phonological encoding was probably completed up to the noun of the adjectival NP. Similar results were obtained by Alario and Caramazza (2002) for the production of French adjectival NPs. In the congruent condition, participants named adjectival NPs for which the determiner is the same when the noun is in a simple NP such as *mon sifflet* (my whistle) or in a complex adjectival NP such as *mon ancien sifflet* (my old whistle). In the incongruent condition, the determiner of the adjectival NPs changed when the noun was in a simple NP as in *ma table* (my table) relative to when it was preceded by a vowel initial adjective as in *mon ancienne table* (my old table). As for their Italian colleagues, Alario and Caramazza obtained longer RTs for the phonological incongruent condition. The results of this study are therefore also in favour of a large span of encoding at the phonological level but also in favour of an influence of the phonological properties of the word on the grammatical encoding level.

II.4 Priming paradigms

Eventually, priming paradigms (also called "interference paradigm") are widely employed by psycholinguists. Participants performing an interference paradigm are asked to produce a target sequence (e.g. name a picture) while ignoring a written or auditory distractor word. Even if the speaker does not pay attention to the distractor word, it has been shown that the system processes it automatically (Stroop effect[11]). This stroop-like paradigm has been widely used in psycholinguistics. If the distractor word is semantically related to the target word, a significant interference effect is expected while no effect occurs with non-semantically related distractors (this condition is illustrated in Figure 6). On the contrary, if the distractor is phonologically related to the target word, a facilitation effect will be expected. This chapter will focus on phonological priming effects. Before that we will briefly review and comment on semantic priming.

[11] The Stroop effect (named after John Ridley Stroop who first reported the effect) designates the interference effect between a target stimulus and a to-be-ignored distractor stimulus. The participant´s reaction times when presented with a target stimulus and its distractor are delayed while no effect is observed while the target stimulus is presented with a neutral non-interfering stimulus.

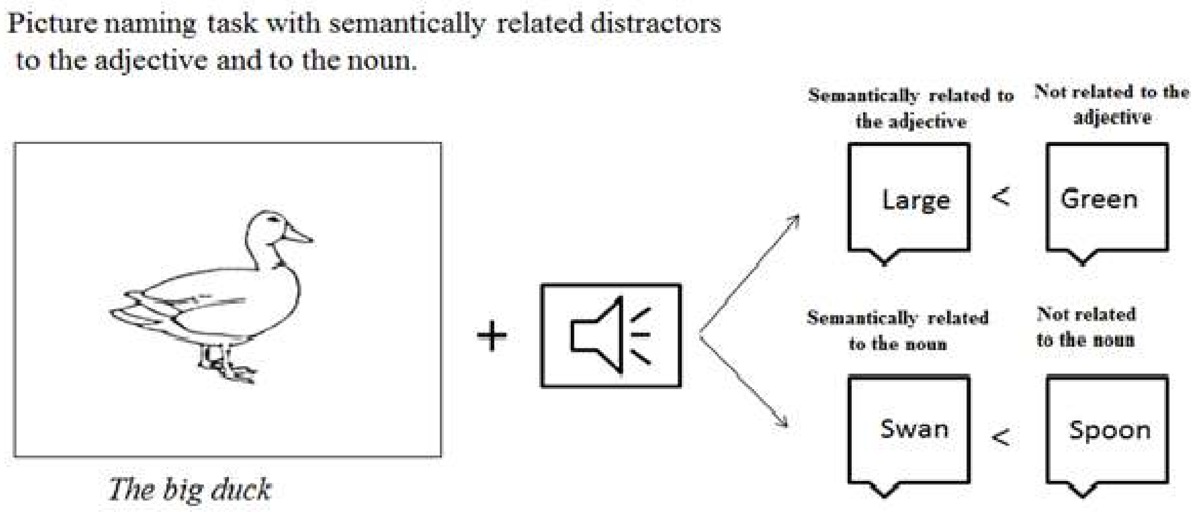

Figure 6. Illustration of a picture naming task wit semantically related distractors. In one condition, the distractor-adjective (*large*) is semantically related to the target-adjective (*big*). Longer reaction times will be measured in the condition than if the adjective is primed by a neutral adjective (*green*). The same process is observed when priming is focused on the noun.

II.4.1 Semantic priming

Even though semantic priming paradigms are widely used, the data reported in the literature diverge a lot. One of the reasons for this is the selection of the material. Recent studies have indeed underlined that semantic interference effect depended on the relative semantic distance between the distractor word and its target word (Costa, Mahon, Savova & Caramazza, 2003; Costa, Alario & Caramazza, 2005; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007, Roelofs, Piai, Schriefers, 2012). Not only is the semantic distance determining but also the category in which the distractors are selected. While a distractor from the same semantic category than the target picture (e.g., "*mouse*" and "*cat*") will lead to interference, an associative distractor (e.g., "*mouse*" and "*cheese*") will not (Alario, Segui, & Ferrand, 2000; Lupker, 1979). The categorization problem of the so-called semantic interference effect is still challenging for models of speech production stipulating that lexical access is made by the competition of the different lexical nodes. If specific semantic distractors lead to no effect or facilitation, then it is indeed rather difficult to account for a selection by competition process. Recent works suggest that semantic interference might not necessarily reflect lexical selection processes or that there is no competition in the process of lexical selection (Janssen, Schirm, Mahon, & Caramazza, 2008; Mahon et al., 2007; Finkbeiner & Caramazza, 2006; Costa, Alario, & Caramazza, 2005; Miozzo & Caramazza, 2003). The interference effect observed would actually be post-lexical and the result of the exclusion of an articulatory response to the distractor word from an output buffer. Recent work by Roelofs, Piai and Schriefers, (2012) actually challenge this model and it seems likely that the question of selection by competition will still lead to further debate in the coming years.

Advance planning at the lexical-semantic level

The question of advance planning at the grammatical encoding level for NPs has been addressed in a study by Meyer (1996). She investigated the span of encoding at the semantic and phonological level in a priming paradigm. She tested word pairs such as *The arrow and the bag* for which each element of the pair was primed by semantic and phonological distractors. She obtained an interference effect from the semantic distractors compared to the neutral condition for both elements of the word pairs. However, a facilitation effect from the phonological distractors compared to the unrelated condition was observed for the first word of the pair only. As it is suggested by the study of speech errors, she concluded that the span of encoding was wider at the lexical level than at the phonological level.

Another study by Schriefers & Teruel (1999a[12]) also investigated advance planning at the grammatical level with a semantic priming paradigm. The authors compared adjectival NPs in German and in French with distractors priming either the noun or the adjective. In German, where the adjective is pre-nominal (A+N), the smallest full syntactic phrase is the entire NP while in French where adjectives can be post-nominal (N+A), the smallest full phrase is the determinant + noun. The question raised in the study was whether the smallest full phrase or the entire NP determined the span of encoding at the grammatical level. Different results were obtained for the two languages with an interference effect for both element in German (A and N in A+N) and only an effect on the noun in French (N in N+A). The authors conclude that these results are in favour of an evidence for cross-linguistic variation of grammatical advance planning. The unit of encoding would therefore be fixed and determined by the smallest full syntactic phrase. These results converge with morpho-syntactic approaches to phonological grouping.

Differently, recent studies underlined that the amount of encoding at the lexical-semantic level might not be fixed but rather determined by some specific constraints, namely inter-individual differences. Wagner, Jescheniak and Schriefers (2010) indeed reported that a

[12] In Schriefers & Teruel (1999a), the smallest full syntactic phrase can be defined as a phrase up to and including the head noun but not including any following elements. In French, the initial element (the noun) is sufficient as a full syntactic phrase (*la table*, the table). In German, however, the adjective alone does not constitute a complete syntactic phrase and the smallest full phrase is therefore the entire phrase with the head noun in final position (*Der gruene Tisch,* The green table).

different factor could affect the span of advanced planning, namely variability in speakers' speech onset latencies. They ran a study where participants were asked to name pictures corresponding to sentences such as *The frog is next to the mug*. Semantic distractors were presented which primed either the first or the second noun of the sentence. Participants were split into two groups according to their onset latencies (speakers with slow or fast onset latencies). The interference effect of the semantic distractors was much smaller for nouns in second position for the "fast" group than for the "slow" group. Similarly to Gillespie and Pearlmutter (2011), the authors concluded that fast speakers show a tendency toward incremental grammatical advance planning while slow speakers present full grammatical advance planning of the entire utterance.

If semantic priming paradigms are very convenient to investigate advance planning at the lexical-semantic level, they also indicate many methodological concerns with diverging priming effects (facilitatory or inhibitory) depending on the type of distractors. It is therefore difficult to disentangle whether the results reported in this literature reflect encoding processes or methodological artefacts. Concerning the span of lexical-semantic encoding, we have seen so far two different accounts: an account suggesting the span of encoding is determined by the smallest full syntactic phrase (fixed unit) by Schriefers and Teruel (1999a) and an account suggesting that the amount of encoding varies across speakers (Wagner et al., 2010). Both accounts will be investigated in the following experiment chapters.

II.4.2 Phonological priming

Encoding of one word

Phonological priming has been less studied than semantic priming but is not less debated. First, when investigating single word priming, many studies reported a facilitation effect when the final phonemes of a prime and its target were overlapping (Dumay, Benraïss, Barriol, Colin, Radeau, & Besson, 2001; Radeau, Morais, & Segui, 1995; Spinelli, Segui, & Radeau, 2001) while others reported an inhibitory effect when the overlapping phonemes were in the initial position (Hamburger & Slowiaczek, 1996, 1999; Slowiaczek & Hamburger, 1992). A facilitation effect for initial segments has also been reported for picture naming experiments (Meyer & Schriefers, 1991, Meyer, 1996; Schriefers & Teruel, 1999b; Starreveld, 2000).

Advance planning at the phonological level

The literature on phonological priming in multiword utterances also presents diverging results.

If Meyer' study presented results in favour of a span of encoding limited to the initial word, most studies do find a facilitation effect at the phonological level for the first word and beyond. Starting with short sequences, Costa and Caramazza (2002) ran a cross-linguistic study in English and Spanish testing adjectival noun phrases. In English the noun is placed after the adjective (e.g. *the red car*) and in Spanish before the adjective (e.g. *el coche rojo*). In this study, the target word was the latest word in the phrase (the noun in English and the adjective in Spanish). Since they obtained a facilitation effect for the prime independently of the language, they concluded that the entire sequence had been encoded at the phonological level before articulation. However, one should note the fact that the authors manipulated two very different languages (a Germanic one and a Romance one) and specific language properties may modulate cognitive mechanisms (Costa, Sebastián-Gallés & Alario, 2006 for a review). For example, in some languages determiners depend on the phonological properties of the following word: e.g. in French "ma vieille armoire", but *mon ancienne armoire* (my old wardrobe): the determiner *mon* is masculine while *armoire* is feminine but because the adjective is starting with a vowel, the selection of the determiner differs. This language specific property might generate different encoding processes in one language compared to a language for which the determiner will always be the same. Moreover, in Costa and Caramazza´ study, the target words were from two different categories (a noun and an adjective) so it is difficult to draw similar conclusions for two different types of grammatical items.

What can be underlined though is that these two different types of NPs also generate two different types of syntactic orders (A+N in English and N+A in Spanish). Their results are therefore not in line with Schriefers and Teruel´s hypothesis[13] (1999a) as the encoding of N+A NPs extends the smallest full syntactic phrase (N in N+A). From these results, it is difficult to see whether syntax or cross-linguistic differences account for the diverging results. This hypothesis was explicitly investigated by Dumay, Damian, Stadthagen-Gonzalez and Perez (2009) and later by Damian, Dumay, Stadthagen-Gonzalez and Perez (submitted) in a cross-linguistic study using the initial phoneme repetition priming paradigm (i.e. phonological

[13] Even though Schriefers & Teruel´s hypothesis makes predictions at the lexical-semantic level, we can infer that if encoding of N+A NPs is limited to the initial word at this level, it cannot be larger at the subsequent level.

priming by repeated onsets such as in *b*lue *b*ag) on different types of NPs. In the two studies, the authors tested one Germanic language (English), where the colour adjectives of the NPs are pre-nominal, and two Romance languages (Spanish and French), where the adjectives are post-nominal. As predicted by Schriefers and Teruel (1999a), they observed phonological facilitation of repeated phonemes for English A+N NPs where the head noun was the second element and failed to obtain an effect of phonological facilitation for the Spanish and French experiments where the head noun was the first element. Nevertheless, the authors suggested that their results might be due to the fact that colour identification might be more difficult than object identification, therefore affecting differently the results when the colour adjective is in first or second position. In a subsequent experiment, they rendered colours more salient and tested participants in English and Spanish. For the English experiment, shorter RTs were reported for the condition where initial phoneme was repeated. Furthermore, the overall naming latencies were shorter for the English experiment, where colours were rendered more salient, relative to the first English experiment, where only coloured line drawings were used. However, for the Spanish experiment, longer RTs were reported for the initial phoneme repetition condition. Overall, these results led the authors to argue for a sequential model of encoding with a level of activation slightly higher for the nouns relative to the adjectives. This model explains why a facilitation effect is observed in the English NP (A+N) condition where the adjective will receive extra facilitation from phonological priming with the noun. However, in the Spanish NP condition (N+A), interference will occur from the priming effect of the adjective with the noun in initial position. In both studies, the authors conclude that their results are not in line with Schriefers and Teruel´s (1999a) since they did not observe cross-linguistic differences in the encoding processes but rather similar underlying mechanism of coding for sequential order influenced by a stronger activation of the noun.

Similarly, Costa and Caramazza (2002) ran a cross-linguistic study in English and Spanish testing adjective-noun phrases in a picture naming task with phonological distractors. In this study, the target word was the latest word in the phrase (the noun in English and the adjective in Spanish). Since they obtained a facilitation effect for the prime independently of the language, they concluded that the entire sequence had been encoded at the phonological level before articulation. Contrary to Dumay et al., (2009) who reported an inhibitory effect of phonological priming by repeated phonemes in N+A sequences in Spanish, Costa and Caramazza (2002) obtained a facilitation effect of phonological primes related to the A.

If all the studies reported so far report a priming effect for the N in A+N NPs, at least one study challenges this otherwise reliable effect. Schriefers and Teruel (1999b) tested A+N NPs in German using a phonological priming paradigm with phonological distractors. The distractor words primed either the first or second syllable of the first word or the first syllable of the second word. They failed to obtain a facilitation effect on the first syllable of the second word across four experiments. Moreover, they also failed to obtain a facilitation effect for the second syllable of the first word. The authors concluded that the minimal unit of encoding could be smaller than the phonological word.

Schnur, Costa and Caramazza (2006) went further and tested complex sentences with noun, adjectives and verbs in a priming paradigm. In this study, they also addressed another important question, namely the question of grammatical boundaries in the phonological encoding processes. With their paradigm, they were also able to distinguish between phonological word boundaries and phrase boundaries. In the first experiment, participants had to produce sentences containing one phonological word and phrase: e.g. [The girl] [jumps] where the phonological distractor was related to the verb. The verb was the second phonological word (and phrase) of the sentence. Spoken latencies were significantly shorter for the related condition than for the unrelated condition. This means that the span of encoding would extend the first PW. These results are consistent with the results showing that the second phonological word of a noun phrase was encoded (Costa & Caramazza, 2002; Jescheniak et al., 2003). Another question addressed in this study is whether the span of phonological encoding extends not only one PW but also the phrase. To test this, Schnur et al. (2006, exp. 2) used the same paradigm as in their first experiment but with line-colored drawings this time. This led to the production of sentences such as: *The orange girl jumps.* In that case, the verb was no longer the second PW but the third one and belonged to the second phrase of the message to be produced. A facilitation effect was again observed suggesting that the message was encoded up to the third PW before articulation and that phrase boundaries did not seem to play a determining role in the encoding process.

A major criticism can be made to Schnur et al´ study though. The literature relating to semantic and phonological priming has been widely investigating the production of NPs but far less is known concerning the production of verbs. In their paper, the authors primed verbs mostly with nouns. To be consistent with the design of their experiment they should have used primes and targets from the same grammatical category. But yet, even they had done so, the question of how verbs are semantically organized is complex. Will a transitive verb behave as an intransitive verb? Will encoding be context dependent? In a paper by Tabossi and Collina (2003) on the picture word interference paradigm in the production of verbs, the authors conclude that it is probably impossible to study semantic knowledge while ignoring conceptual knowledge since the two of them are so tightly entangled. Probably aware of some of these issues, Schnur (2011) decided to replicate her results using a slightly different approach. To make sure that encoding of the phrase was not due to the semantic or syntactic relevance of the verb, she tested similar sentences with different grammatical structures. In this study, the sentences contained a verb but also a subject and an object. So the verb was no longer the latest element in the sentence. In a first experiment, the verb was primed phonologically. In a second experiment, the frequency of the object noun was manipulated. In the last experiment, the object noun was primed phonologically. She obtained both a priming effect on all the elements of the sentences and a frequency effect. It is to note though that once again phonological distractors were of a different syntactic category than the targets.

Another criticism can be underlined for studies on the production of several words using a picture naming task. As Oppermann, Jescheniak and Schriefers (2010) observed, the presence of an object in a visual display can activate its phonology even though the object is not meant to be named (see Oppermann et al. 2010 for a review). So, all the studies reporting results in favour of a span of encoding extending the PW might actually have obtained these results because of this effect. Oppermann et al, (2010) therefore tested this in an original study using various syntactic formats in German. In this study, participants saw sentences with different syntactic orders and were then asked to remember them on the presentation of a cue. Phonological distractors were used at different stimulus onset asynchrony (SOAs)[14]. This method helped avoiding the presence of several objects in the visual display. The results obtained were similar to these of Schnur et al, (2006) and the authors concluded that the span of phonological encoding extended a single syntactic phrase and maybe an entire simple sentence. Smith and Wheeldon (1999) also obtained results in favour of a phrasal scope of planning using a picture naming task comparing the production of complex NPs vs. simple NPs. Their results were replicated by Martin, Crowther, Knight and Tamborello (2010) using a similar paradigm thus supporting the phrasal scope of planning hypothesis.

A different type of priming paradigm was used by Damian and Dumay (2009) to investigate the span of encoding of NPs. They explored phonological encoding through repeated segments. In their study, they presented participants with two sets of pictures. The first set

[14] The stimulus onset asynchrony is the time interval between the onset of a first stimulus and the onset of a second stimulus. In the cited study for example, the auditory distractors were presented either at the same time as the picture (SOA 0 ms) or 150 ms after the presentation of the target picture or even 300 ms after. As we will see later in the discussion the time interval selected between the presentation of the target picture and its distractors can lead to different effect and might interfere with different levels.

was composed of coloured objects such as "*green goat*" where the initial phoneme was repeated. In the other set the initial segments were different. If planning ahead extended the first word, then a facilitation effect with shorter RTs should be observed due to the priming effect of the repetition of the phoneme. If encoding was limited to the first word, no difference in RTs should be observed. This set reported shorter naming latencies than the second set where the coloured objects had different onsets. This same study indicated that this paradigm did not only work with onsets of the pairs but also with segments positioned elsewhere in the word (e.g. *green flag*). Since the second word of the sequence seemed to influence the encoding of the first word, their results allowed them to conclude that in the production of several words, word forms were all activated before articulation.

The authors attempted to replicate their results (Damian et al., submitted) using the same paradigm with Spanish and French adjectival NPs with post-nominal adjectives but failed to obtain a facilitation effect. They deduced that this was due to the fact that encoding processes might be driven by the noun (what) and not the adjective (how). In that case, if nouns were more easily retrieved than adjectives, one could expect to obtain a facilitation effect in A+N structures (in English) where then noun would "help" the adjective. To test this hypothesis, they superimposed coloured rectangles on the black and grey images instead of having coloured-line drawings. The colour being more salient should help the retrieval of the adjective in N+A structures (Spanish and French). They did obtain an effect for adjectival NPs in Spanish[15] by manipulating the presentation of the stimuli. However, it is to note that the effect was inhibitory though.

Using a similar paradigm, Janssen and Caramazza (2009) presented diverging results. They presented their participants with different types of multiword utterances for which the words' onsets phonology was manipulated in a picture naming task. Phonological onset relatedness led to very different effects depending on the type of utterance tested. For noun+noun utterances, an inhibitory effect was reported while no effect was reported for noun+adjective utterances. However, grammatically canonical structures such as adjective+noun, noun+verb, adjective+adjective+noun led to a facilitation effect. As the Alario and Caramazza' study (2002), the authors conclude that these results are in favour of a non-dissociation of the two levels of processing (grammatical and phonological) since the effect of onset relatedness was dependent on the utterance type.

[15] French was not tested again in their second experiment.

However, if some of these studies report results in favour of a large span of encoding at the phonological level, what they also report is an inhibitory effect from distractors phonologically related to words in a non-initial phrase of the utterance. Jescheniak, Schriefers and Hantsch (2003) reported confusing results with both a facilitation effect and an inhibitory effect. This study included several grammatical structures (bare noun, determiner + noun and determiner + adjective + adjective + noun) with written distractors appearing at various SOAs (+0, +150, +300 ms). The priming effect was significant for the bare noun condition at all the SOAs tested but as soon as the utterances became more complex the facilitation effect not only decreased but also became inhibitory. As their colleagues Oppermann et al. (2010), they explained their results relying on Jescheniak et al.'s (2003) graded activation account. In this account, the authors suggest that the earliest element of the utterance will receive the highest activation while the others' will decrease. Elements outside the scope of phonological encoding will receive no activation and should therefore present no effect whatsoever if primed phonologically. On the contrary, primed elements being in the first position of the utterance and within the scope of phonological planning will show a clear facilitation effect. However, primed elements occurring at a later position in the utterance and being still in the scope of phonological planning will show a decrease of activation or might even present an inhibitory effect. The reason for this is that conflict will occur between the "natural" priming of the initial element of the utterance and the "induced" priming of the latter one. So, shifting the SOA to a later time window when priming an element in non-initial position in the sentence will allow its effect to arise better than with an earlier SOA. We will discuss this point further in the light of the results of our Experiment 2 in Chapter 4.

Even though Meyer´ study (1996) is one of the few to report results in favour of a span of encoding limited to one word, her results follow Jescheniak et al.'s (2003) reasoning. Meyer tested sequences of two NPs such as "the arrow and the bag" in a phonological priming paradigm. She obtained a facilitation effect for the first NP only but an inhibitory effect (20 ms) for the second NP at SOA 0 and +300 ms for Experiment 3 and 4.

II.4.3 The choice of SOAs in priming studies

Here we can note that the choice of SOAs is also very important in the design of a priming paradigm. The choice of the SOA is dependent on the phonological priming effect but its locus is still argued quite a lot. Many studies reported a facilitation effect only when using specific SOAs. The fact that there does not seem to be a universal SOA which would guaranty a priming effect makes it difficult to decide which one to use. In the literature of phonological priming, a lot of contrastive results have been reported. Negative SOAs especially have been subjected to a lot of debate. Schriefers, Meyer and Levelt (1990) observed no facilitation effect with a negative SOA of -150 ms in a priming paradigm using auditory distractors while other studies reported a facilitation effect for SOAs varying from -100 ms (Damian & Martin, 1999), -150 ms (Meyers & Schriefers, 1991) and as early SOAs as -300 ms (Starreveld, 2000). It is to note, however, that Starreveld (2000) attributed this very early facilitation effect to a strategy of the participants who might have understood the relationship between distractors and pictures from the previous blocks. Jescheniak and Schriefers (2001) tested this hypothesis but they obtained a facilitation effect at SOA -300ms no matter which block the negative SOAs were tested in. Positive SOAs seem to be slightly more reliable. In her study, Meyer (1996) used four different SOAs (0, +150, +300 and +450 ms). The first three SOAs all led to a facilitation effect on the first word but nothing at SOA +450 ms while no effect was reported on the second word of the pairs but the small inhibitory effect. In the same line, Oppermann et al. (2010) also obtained a facilitation effect at SOA 0 ms, +150 ms, +300 ms but nothing at +400 ms. The choice of SOA is therefore very strategic and we cannot rule out that some studies might have reported different results with the use of different SOA. We will investigate this hypothesis further in the review of the literature.

This brief review of the literature focusing on experimental priming paradigms in the study of encoding processed involved in the production of several words is only shedding light on the many divergences remaining from a methodological and a theoretical point of view. The results of studies using priming paradigms in the production of several words is very confusing varying from facilitation effects (Costa & Caramazza, 2002; Alario & Caramazza, 2002; Miozzo & Caramazza, 1999; Schnur et al, 2006, 2011, Oppermann et al., 2010) to no effect (Meyer, 1996; Wheeldon & Lahiri, 1997) or even to inhibitory effects of phonologically related words (Schriefers & Teruel, 1999a; Jescheniak, Schriefers & Hantsch 2003; Meyer, 2006 and Oppermann et al., 2010) when priming the second or third word of a sequence. We do not seem to find a specific pattern in these results whether we look at the language group (Germanic vs. Romance), the grammatical structure of the utterance tested, the type of SOA selected or even the paradigm chosen. All these studies vary a lot in their format and the interpretation of their results and it is still difficult to see whether the effects obtained are induced by the experimental paradigm used or if they do reflect speech processes.

Still, although there is not a very clear pattern arising from these results whether we group them according to languages (Germanic vs. Romance) the grammatical structure of the utterance tested or even the paradigm chosen, some trends emerge from the different studies. It seems indeed that it is more difficult to obtain a strong priming effect beyond the first word for Romance languages such as Spanish (Navarrete & Costa, 2005), French (Schriefers & Teruel, 1999a, Dumay et al., 1999; Damian et al, submitted) and Italian (Miozzo & Caramazza, 1999). Only one study by Costa & Caramazza (2002) reports a priming effect for the second word in N+A. While studies on English and German (Damian & Dumay, 2007, 2009, Schnur et al, 2006, Schnur, 2011; Oppermann et al., 2010) very often report a span of encoding comprising the entire message, from simple NPs to verbal sentences. Only one study by Schriefers and Teruel (1999b) failed to report an effect on N in A+N. Whether cross-linguistic differences, syntax or speech production context modulate the span of encoding, it is difficult to say in the light of this review of the literature.

II.5 Conclusion

The span of encoding of adjective NPs has been investigated in many different languages with different structure and very different results were reported. From the review of the psycholinguistic literature, it is difficult to disentangle what determines the span of encoding. Syntax and cross-linguistic differences could be potential candidates to account for these results but many counter-examples are reported. To find coherence in the diverging interpretations, we will now integrate some linguistic observations from Chapter 1 into the current conclusion.

On the one hand, part of the linguistic literature on the comparison between A+N and N+A suggests that A+N structures are a “default” structure in French. We recall that A+N NPs are the eldest structure in French while N+A are more recent structures (section I.6.1). Furthermore, theories of Universal Grammar suggest that A+N structures are the canonical structure while N+A structures are more syntactically complex as they are the result of a syntactic movement with the noun rising higher than the adjective (section I.5.2). These arguments actually converge with the fact that it seems easier to obtain phonological priming on the second word of a A+N NP while encoding of the second word in N+A seems more difficult to obtain. As “default” structures, A+N structures might present easier and faster encoding processes while encoding processes involved in N+A might be less systematic. Moreover, post-nominal adjectives in French (and probably in other Romance languages for which the adjective can be pre-nominal and post-nominal) are described as being more independent of the noun while pre-nominal adjectives and their nouns form a unique entity (Waugh, 1977). This would be an additional clue to the suggestion of a larger span of encoding for A+N relative to N+A.

It is to note that these diverging results do not only suggest different encoding processes for NPs of different syntactic structures but similar phonological length. What they also suggest is that the minimal unit of encoding might not be the initial word. If the minimal unit of encoding was the initial word, then different syntactic structures of the NP would not influence encoding processes involved in the production of NPs. Chapter 3 will investigate these questions further by first comparing the production of one word versus two words and second compare the production of pre-nominal and post-nominal adjective-noun phrases.

Chapter 3: Encoding of simple noun-phrases versus adjective-noun phrases

III.1 Introduction

This first experimental chapter has several goals. First, we examine whether production of one word (1W) differs from production of two words (2W) NPs. To this aim, we compare the production of single nouns to two different types of adjective-noun phrases (NP condition). If production of 2W NPs takes longer than production of 1W, we can infer that encoding of 2W NPs extends beyond the initial word before articulation. Second, we verify whether two different types of adjective-noun phrases present different or similar encoding patterns. Here we compare the production of pre-nominal adjective-noun phrases (A+N) to the production of post-nominal adjective-noun phrases (N+A). Adjective-noun phrases in French are indeed very complex and generate many questions. Not only can they present different syntactic structures with adjectives placed before or after the noun, they can also present very different phonological patterns depending on speech context (cf. Chapter 1). As French allows to investigate both types of NPs, we can use this "order" condition to examine whether two NPs of similar phonological length but different syntactic structures present different encoding patterns. This hypothesis is perfectly plausible with cross-linguistic studies (Schriefers & Teruel, 1999a) showing different encoding patterns for different language types (Germanic versus Romance languages). Finally, we investigate several predictors which may be relevant in the study of encoding processes involved in the production of NPs in French. These predictors are phonological length, frequency of the NP sequence, frequencies of the different elements of the NPs and the preferred position of the adjective within the NP. We will now detail the choice of paradigms and of variables we selected to investigate whether A+N and N+A present different encoding patterns.

Choice of paradigms

As we mentioned in Chapter 2, picture naming tasks (PNT) and reading tasks both present advantages and weaknesses. In this chapter, as far as the stimuli and the controlled variables allow it, we will base our experiments on picture naming tasks. However, the use of reading tasks as control of the picture naming tasks, or as part of full experiments will sometimes be required. First, as the stimuli involved in the PNTs presented in this section are visually complex, reading tasks allow to determine whether the effect reported in the PNT might be visual effects linked to the pictures or not. Second, the elicitation of specific adjectives from pictorial stimuli is sometimes not possible. As we wish to integrate some specific variables to the adjectives such as the preferred position of the adjective within a NP, we will have to base one of the experiments on a reading task only. Importantly, as we will expose it later, the replication of an effect across tasks in the experiments using the exact same stimuli with both paradigms (Experiment 1.a and b and 2.a and b.) allows us to use a reading task in Experiment 3 to address the same question.

Length effect

The reason for integrating the length effect to this study is particularly relevant for the comparison between the production of one word and two words. The assumption with the manipulation of phonological length is as follows: a significant length effect converges with most models of speech production which argue for a sequential and serial ordering of phonological segments at the phonological encoding level (Levelt, Roelofs, & Meyer, 1999; Levelt & Wheeldon, 1994; Roelofs, 2004). According to these models, the generation of additional segments should delay naming processes in a picture naming task. Therefore, if we observe a difference between encoding of one bisyllabic word relative to the encoding of two monosyllabic words, we can infer that, in the production of French NPs, bisyllabic single words are probably encoded faster than two monosyllabic words.

However, we need to underline that the length effect is quite debated in the literature. We will briefly introduce the different results discussing the length effect in this section in order to integrate them to the discussion of the current study.

The hypothesis according to which phonological length should delay naming latencies was tested by different authors in the production of single words but the results are very complex. Some studies did report a length effect (Santiago, MacKay, Palma, & Rho, 2000) with short and long stimuli intermixed, some reported a length effect only when the short and long stimuli were split into *pure* blocks (Meyer, Roelofs & Levelt, 2003; Meyer, Belke, Häcker, & Mortensen, 2007) and others failed to replicate this effect (Bachoud-Levi, Cohen, Dupoux, & Mehler, 1998; Roelofs, 2002; Damian, Bowers, Stadthagen-Gonzalez & Spalek, 2010). However, in all these studies, phonological length was manipulated as an experimental factor and not included as a predictor in a multiple regression analysis. Those studies which conducted a similar analysis (Alario, Ferrand, Laganaro, New, Frauenfelder, & Segui, 2004) failed to report a length effect. Some accounts suggest that what was reported as a length effect was actually likely to be a syllabic structure effect and was probably language specific (Santiago et al, 2002). The authors conclude that the fact that this effect may differ across languages might explain the diverging results from the literature on phonological length.

Most relevant to our study, the length effect was also investigated for the production of word pairs in an additional eye-tracking study by Meyer et al, (2003, experiment 4). The name of the first word was either monosyllabic or disyllabic and gaze durations were reported to be shorter for the monosyllabic condition relative to the disyllabic condition. In a fairly similar experiment, Griffin (2003) reported a reversed length effect for both gaze duration and reaction times. In her experiment, participants were asked to name pair of content words without pause. The purpose of the experiment was to determine whether speakers can use word length to coordinate the timing of word preparation. The author reported longer naming latencies when the first word of the pair was monosyllabic (wig-carrot) than when it was disyllabic (windmill-carrot). She also reported longer gaze at the second word of the pair before speech onset. She concluded that when the initial word was short, its pronunciation was also short and allowed for less ahead planning of the second word. Therefore, when presented with a short initial word, speakers decided to delay speech articulation to allow for more preparation time. In the study by Meyer et al. (2007), the length effect was obtained by varying length from one to three syllables (in pure blocks). To account for the results of the literature focusing on the length effect, we suggest the following: as Griffin´s argument according to which speakers use encoding strategies based on length estimates to plan the second word of their message, we hypothesize that the length effect is indeed subject to speakers' strategies. As speakers strategies imply greater variability (as we will see in the following chapter), it might therefore be easier to show an effect of variability with "larger" differences in terms of syllables (1 versus 3 syllables relative to 1 versus 2 syllables) in such a paradigm.

Frequency of the sequence

While most studies from the literature investigating encoding processes in the production of adjective-noun phrase only consider the frequency of the nouns and of the adjectives (Costa & Caramazza, 2002; Alario et al., 2002; Schnur et al., 2011), a recent study by Janssen and Barber (2012) tested the frequency of the entire sequence. To do so, they looked up the frequency of each of their NPs sequences in the Google search engine. More and more studies (Blair, Urla & Ma, 2002; Keller & Lapata, 2003; Janssen & Barber, 2012) indeed showed that it is perfectly reliable to use internet search engines to estimate word and sentence frequency. We will therefore use this additional measure to balance our stimuli across order condition (A+N and N+A) and make sure that a difference between the A+N and N+A condition is not the result of an unbalanced frequency of the sequence across condition. Additionally, Experiment 2 will also investigate whether the frequency of the sequence can be a predictor of the naming latencies in the production of French NPs as proposed by Janssen and Barber (2012).

Preferred position of the adjective

Finally, as we examine the production of French NPs with a specific focus on the order constraint (A+N and N+A), we will integrate the preferred position of the adjective within an adjective-noun phrase in the last experiment of this chapter. We underlined in Chapter 1 the fact that the position of the adjective in French is not random and reflects different linguistic and cognitive constraints (Thuilier, 2012). However, the preferred position of the adjective within a NP is probably never taken into account when selecting psycholinguistic material.

The experiments

Here we conducted five experiments in which we compared the production of three different types of NPs. In the first study (Experiment 1.a and 1.b), we compared NPs composed of same syntactic elements (a noun and an adjective) but with two different structures: one with a pre-nominal adjective A+N (*cinq*[16] *chats*), and one with a post-nominal adjective N+A (*chat jaune*). We manipulated the length of the noun and compared these two-word NPs to single noun productions. We observed similar results with a picture naming (Exp.1.a) and a reading task (Exp. 1.b) namely shorter latencies for the single noun condition vs. the two two-word conditions (NP condition) and longer latencies for the N+A condition than for the A+N condition (order condition). No effect of length of the noun was observed. In Experiment 2.a (picture naming) and 2.b (reading), we replicated the “order effect” with a better match of frequencies (lexical frequencies of the adjective and the noun and frequency of the entire NP sequence) across conditions (A+N and N+A). The order effect was replicated despite a better match across frequencies thus ruling out the hypothesis that the order effect was due to unbalanced frequencies in the material. Additionally, a length effect was reported in the naming and reading task. Finally, we report a frequency effect of the adjectives in the naming task but not in the reading task. In Experiment 3, we investigate whether the frequency of the adjectives (which were fewer than the nouns in the previous experiments and therefore repeated more often) can account for the shorter naming latencies in A+N relative to N+A in

[16] Numbers can be considered as adjectives but also determiners (See Riegel, Pellat & Rioul, 1994). The use of numbers as adjectives can therefore be questionable for linguists. However, it is not easy to create pictures that can elicit adjectival NPs in one picture only. We are well aware that this is a serious weakness to the mentioned experiment and will avoid the problem with the following experiments.

the previous experiments. We compared NPs composed of exactly the same elements (adjective + noun) but in both order conditions (A+N: *immense voiture* vs. N+A: *voiture immense*) in a reading task. Moreover, we also controlled for the frequency of the sequence across conditions. The order effect remains despite a perfectly balanced material. Post hoc analyses on the material show that the stimuli are not balanced in terms of preferred position of the adjectives: A+N sequences are composed of adjectives for which the preferred position is respected while N+A sequences contain adjectives for which the preferred position is not respected. To test whether the preferred position of the adjective within a NP can be a predictor of RTs, we carried post hoc analyses on a subset of stimuli for which the post-position is favored in the N+A condition with the prediction that the order effect should reverse (shorter naming latencies for N+A relative to A+N). Results show that the order effect disappears but is not reversed.

III.2 EXPERIMENT 1.a

In this experiment, we investigate production latencies of one word (1W) versus two word (2W) NPs. We also examine whether production of A+N NPs differ from production of N+A NPs in a picture naming task. We used same syntactic units (a noun and an adjective) in two different syntactic orders: one with a pre-nominal adjective A+N (*cinq chats*) and one with a post-nominal adjective N+A (*chat jaune*). The nouns were the same in all conditions and we manipulated their length in syllables (monosyllabic vs. disyllabic nouns); the adjectives were all monosyllabic. Thus, in one condition the 2W NP has the same length in syllables than in the disyllabic single noun condition. If production latencies do not differ across NP conditions (N, A+N and N+A), this would suggest that only one element of the NP is encoded before articulation. If more than one word is encoded before speakers start articulating, production latencies should be shorter for single word (N) than for 2W NPs (A+N and N+A). In this case, the manipulation of length will allow us to disentangle whether this is a pure length effect or an “additional word effect”. Finally, if a difference is observed between A+N and N+A this may indicate that word order (syntax) plays a role in determining encoding modalities.

Method

Participants

Twenty French speaking undergraduate students took part in the experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Materials

Forty eight nouns and their corresponding pictures were selected from two French databases (Alario & Ferrand, 1999 and Bonin et al, 2003). For the 2W NPs the nouns were combined with four monosyllabic adjectives: two were quantitative adjectives (*deux* -two and *cinq* **-**five) and two were colour adjectives (*vert* -green and rouge *-red*). Half of the stimuli were randomly assigned to one of the pre-nominal and one of the post-nominal adjectives. One hundred and forty four noun phrases were created: 48 were single nouns (N), 24 NPs were nouns associated with the adjective *rouge* and 24 NPs were nouns associated with the adjective *vert* (noun+adjective structure: A+N); 24 NPs were nouns associated with the adjective *deux*, and 24 NPs were nouns associated with the adjective *cinq* (adjective+noun structure: N+A). A+N and N+A will be referred to as the "order condition".

Half of the nouns were monosyllabic (short condition) and the other half were disyllabic nouns (long condition), matched on a set of pertinent psycholinguistic factors taken from the same databases (see Table 1[17]). In addition, nouns were matched on the sonority of the first phoneme[18] to each of the quantitative adjectives. This was done to have similar onsets in the conditions where the noun was in the first and second position and therefore have similar voice key sensitivity in each condition. As all nouns were combined in all conditions, half of the A+N and N+A stimuli had same length in syllables as half of the single N (disyllabic stimuli). The list of the stimuli is presented in Appendix 1.

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[17] These psycholinguistic factors are commonly used in PNT. Name agreement is the extent to which people agree on the name given to a specific picture. Familiarity is the degree of familiarity of the concept represented by the picture. The highest the name agreement or familiarity, the fastest the picture will be named. Visual complexity is the amount of details of the picture. The name of visually complex pictures will be retrieved more slowly than less visually complex pictures. Age of acquisition is the mean age at which a name is acquired. Early acquired words are produced faster than late acquired word. Eventually, a highly frequent word is produced faster than a low frequent word (Alario et al., 2002).

[18] It has been shown that voice key measurements are sensitive to the initial phoneme of the response (Kessler, Treiman, & Mullenix, 2002). Not all types of phonemes are detected with the same precision. Therefore, the selection of phonemes with similar sonority avoids biases in the reaction time measurements.

Table 1

Properties of the Forty Eight N Stimuli.

	NA	FAM	COM	AA	FREQ
Short	0.18 (0.25)	3.08 (1.07)	2.90 (0.84)	2.16 (0.47)	13.87 (11.03)
Long	0.14 (0.18)	3.01 (1.11)	2.92 (0.86)	2.07 (0.47)	13.88 (8.87)
***p* values**	0.59	0.84	0.93	0.5	0.99

Note: NA = Name agreement; FAM = Familiarity, AA= Age of acquisition, COM = visual complexity; FREQ = lexical frequency per million words: Values from *LEXIQUE2*, New et al. (2004).

In the N condition, the corresponding pictures were black line drawings presented in the middle of a white square (397 x 328 pixels). In the N+A condition, the same line drawings were coloured and also presented in the same format. In the A+N condition, the black line drawings were multiplied according to the quantitative adjective and presented in squares of the same dimension (397 x 328 pixels). They were spatially organized as 2 and 5 on a dice (see Appendix 2).

In order to reduce repetition and to vary the structure, we included sixty filler items in total. These were composed of different nouns, monosyllabic and bisyllabic, and four different adjectives, two quantitative and two colours (*trois* -three and *quatre* -four, *jaune* -yellow and *bleu* -blue).

Procedure

Before the experiment, participants were familiarized with all the pictures and their corresponding names on a paper sheet. Stimulus presentation was controlled by the E-prime software (E-Studio). The stimuli appeared on a computer screen and participants were instructed to name them aloud as quickly and as accurately as possible. Before the presentation of each stimulus, a fixation cross stayed on the screen for 500 ms. The stimulus appeared 200 ms after and remained on the screen for 3000 ms. A blank screen followed and stayed for 2000 ms before the next trial. The experiment lasted about forty minutes with three breaks included. The experiment was divided in four blocks of sixty two stimuli each. Within each block the trials were in a different pseudo-randomized[19] order for each subject. Naming latencies of the noun phrases were measured by means of a voice key. Reaction times were measured starting from the onset of the sequence to the beginning of the naming response. The experiment started with a training session including fillers for each condition.

Results

One subject was removed from the final analysis because a high error rate. Reaction times were systematically checked with speech analyser software. Errors, no responses, technical RT errors as well as RTs above 1450 ms and below 450 ms were discarded from the analysis. A total of 7% of the RTs was therefore removed. Spoken latencies data were fitted with linear regression mixed models (Baayen, Davidson & Bates, 2008) using the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors. The NP condition: (A+N, N+A) and syllabic length (short, long) were included in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. We controlled by-participants and by-items random adjustments to intercepts. Results are presented in Table 2. Production latencies are 33 ms faster for single N production than for the fastest 2W condition (A+N).

[19] As the order in which the stimuli are presented can influence the results (the repetition of the same item for instance or two subsequent items from the same semantic category, see Howard, Nickels, Coltheart & Cole-Virtue 2006), it is often advised to use pseudo-randomization in psycholinguistics. This “controlled” randomization allows to make sure that the stimuli are distributed in a way where one trial will not affect the next one.

Table 2

Mean Naming Latencies (ms) and Error Rates (%) for the Three Conditions of Noun-Phrases and Length.

	Mean (SD)			**Error (%)**		
	N	**A+N**	**N+A**	**N**	**A+N**	**N+A**
Short	760 (128)	794 (123)	818 (138)	0.4	0.7	0.9
Long	757 (137)	787 (142)	813 (152)	0.6	0.8	1.2
Total	758 (133)	791 (133)	816 (145)	0.9	1.5	2.2

Order effect	**Difference (ms)**	**Length effect**	**Difference (ms)**
N-A+N	-33	N short-long	-3
N-N+A	-58	A+N short-long	-7
A+N-N+A	-25	N+A short-long	-5

Note: numbers in brackets are Standard Deviation for each average

The main effect of NP condition is significant (F(2, 2577) = 10.321 *p*<.0001), but no effect of length is observed (F<1), and no interaction between length and NP condition: (Fs<1).

Contrasts were used to verify which conditions were significantly different. Spoken latencies for the N condition are shorter than all the other conditions (N vs. A+N: t(2574) = 2.54 *p*<.0110; N vs. N+A: t(2574) = 4.52 *p*<.00001. Naming latencies for the A+N condition are 25 ms faster than the N+A (A+N vs. N+A: t(2574) = 1.98 *p*<.05).

The error rate differs marginally between the N and A+N condition (z=-1.850, *p*<.06), the A+N and N+A condition (z=1.877, *p*<.06) but significantly for the N condition compared to the N+A condition (z= 3.605, *p*<.0001).

We carried post hoc comparisons between disyllabic single N versus bisyllabic 2W NPs (i.e. monosyllabic N + monosyllabic A) and report a difference for the NP condition between the three types of NPs of similar length (F(2, 1195) = 5.618, *p* < .003). A difference is indeed observed for N and A+N ($t(1195) = 2.06$, $p < .04$) and for N and N+A ($t(1195) = 3.32$, $p < .0009$).

DISCUSSION

Length effect

The results from this experiment show that naming latencies for the production of two word sequences are slower than for the production of a single word with no effect of phonological length. The comparison between single bisyllabic N with 2W NPs (monosyllabic N and monosyllabic A) reveals differences in production latencies (i.e. despite similar phonological length). This difference suggests that bisyllabic single words are probably encoded faster than two monosyllabic words.

NP condition

Two general explanations can account for this result. First, longer naming latencies for the production of 2W NPs relative to a single noun might suggest that at certain encoding levels, two words, or at least part of the second word, are encoded before articulation of the first word can start. Second, both two-word conditions are visually more complex than the single word condition; therefore visual processes might carry the RT difference. In that case, only one word is encoded in all conditions, but the visual processes take longer in the A+N and N+A conditions.

However, naming latencies were also faster for the A+N condition than for the N+A condition. As the A+N condition (two to five elements) is visually more complex than the N and N+A condition, all differences between conditions are probably not accounted for by visual processes. It rather suggests that in the two-word condition more than the first element of the sequence is encoded up to a certain encoding level. The possible influence of visual processes will be addressed directly in Chapter 5.

Order condition

Crucially, shorter latencies in the A+N than N+A condition were observed on two-word sequences of same phonological length, but different structure. The 25 ms longer latencies for N+A relative to A+N may originate at different encoding levels. First, speakers may use different encoding strategies with different syntactic structures. Shorter latencies for the A+N condition compared to the N+A condition suggest that encoding processes are different at a specific level, but we are unable at this point to determine at which exact encoding process the difference arises.

Concerns with the design of Experiment 1.a

The reason we report shorter naming latencies for A+N than for N+A sequences could be due to visual effects. Indeed, in the A+N condition several pictures appeared on the screen, (either 2 or 5 in the target conditions). The visual complexity of the A+N condition might actually lead to a specific "recognition" pattern which facilitates identification of this condition. According to Treisman and Gelade's Feature Integration Theory (1980), visual features are first registered without even the use of attention and then coded in parallel across the visual field. In the case of the A+N condition, quantitative adjectives were used. Therefore several items appeared on the screen. Participants might have first integrated the spatial visual information without even integrating the object information. Once the quantitative adjectives were integrated, they would start focusing on the actual target object. If this is the case, then the shorter naming latencies for A+N might just be due to this pop-out effect (the fact that the adjective is rendered more salient by the visual system and put forward compared to the noun). In the case of the N+A condition where the object and the colour are only one item, participants are forced to integrate them together and not selectively (one after the other). Longer naming latencies for the N+A condition might therefore be due to the fact that both elements have to be integrated visually before participants can start encoding them.

In sum, several explanations might account for these results and will be further analyzed in the following experiments. First, we tried to replicate these results and rule out the hypothesis that the difference obtained between A+N and N+A are pure visual effects. To do so, we ran Experiment 1.b which was a reading task using the exact same stimuli as in Experiment 1.a. If visual processes linked to different picture arrangements in the picture naming task are involved in the "order effect" observed in Experiment 1.a, this difference should not be observed in a reading task. The different analyses will be described after discussing the result of Experiment 1.b.

III.3 EXPERIMENT 1.b

This experiment was a reading task using the same stimuli as in Experiment 1.a. Replicating results observed in Experiment 1.a with a reading task should rule out a visual explanation linked to picture arrangements for the "order effect".

Method

Participants

Thirty one French speaking undergraduate students took part in the experiment. None of them had participated in the previous experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Materials

We used the exact same 144 stimuli (48 single N, 48 A+N, 48 N+A) as in Experiment 1.a in a reading task. The written stimuli were displayed in Arial Narrow 16 in the center of the screen.

Procedure

Stimulus presentation was controlled by the DMDX software (Forster & Forster, 2003). The stimuli appeared on a computer screen and participants were instructed to read them aloud as quickly and as accurately as possible. Before the presentation of each stimulus, a fixation cross stayed on the screen for 500 ms followed. The stimulus appeared 200 ms after and remained on the screen for 800 ms. A blank screen would then follow and stay for 500 ms. The experiment lasted about fifteen minutes with three breaks included. Within each block the trials were pseudo-randomized to maximize distance between similar stimuli. Naming latencies of the noun phrases were measured by means of a voice key. Reaction times were measured starting from the onset of the sequence to the beginning of the naming response. The experiment started with a training session with two stimuli.

Results

The DMDX software generates a list of reaction times for each trial. However, voice key errors are sometimes generated. For instance, if a participant breathes too heavily, the voice key can sometimes confuse breath noise as the onset of the response. Therefore, reaction times were systematically checked and corrected with speech analyser software. Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical RT errors were discarded from the analysis and reaction times above 860 and below 260 ms were withdrawn from the data analysis. A total of 2% of the RTs was therefore removed. Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). The NP condition (N, A+N, N+A) and length (short, long) were included in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors. Results are presented in Table 3.

Table 3

Mean Naming Latencies (ms) and Error Rates (%) for the Three Conditions of Noun Phrases and Length.

	Mean (SD)			***Error (%)***		
	N	**A+N**	**N+A**	**N**	**A+N**	**N+A**
Short	457 (54)	477 (61)	504 (65)	0	0.30	0.38
Long	452 (53)	484 (59)	506 (69)	0.03	0.16	0.32
Total	454 (53)	480 (59)	506 (67)	0.03	0.46	0.70

Order effect	**Difference (ms)**	**Length effect**	**Difference (ms)**
N-A+N	-26	N short-long	-5
N-N+A	-50	A+N short-long	7
A+N-N+A	-24	N+A short-long	-2

Note: numbers in brackets are Standard Deviation for each average

Reading single N is 26 ms faster than the fastest 2W condition (A+N); in addition, reading a A+N sequence is 24 ms faster than N+A sequences (Table 5). The main effect of order ($F(3655) = 41.1889$ $p<.0001$) is significant with no length effect and no interaction between NP and length (Fs>1).

Planned comparisons were used to verify which NPs conditions were significantly different. Spoken latencies for the N condition are shorter than both 2W NP conditions (N vs. A+N:

t(3655) = -2.45 p<.01; N vs. N+A: t(3655) = 2.73 p<.0063. Naming latencies for the A+N condition are significantly shorter than the N+A (A+N vs. N+A: t(3655) = 3.45 p<.0001).

The error rate shows a difference for the single N condition relative to the A+N condition (z= -2.040, p<0.04) and also relative to the N+A condition (z=2.44, p< 0.014) but no difference between the two 2W NPs (z<1).

As for the naming task, we carried post hoc comparisons between bisyllabic single N versus disyllabic 2W NPs (i.e. monosyllabic N + monosyllabic A) and also report a difference for the NP condition between the three types of NPs of similar length (F(2, 1735) = 23.25, p < .0001). A difference is observed for N and A+N (t (1735) = 3.29, p < .001) and for N and N+A (t(1735) = 6.82, p < .0001).

DISCUSSION

NP condition

Similar results to Experiment 1.a were obtained with Experiment 1.b. RTs for the A+N condition were 24 ms faster than the N+A condition and production of single N was faster than the two 2W conditions.

Length effect

The same difference between the production of single bisyllabic words and two monosyllabic words in the naming task is reported for this reading task. This is an additional clue to the fact that encoding processes in the production of 2W extend beyond the initial word.

Order condition

First, this experiment allows us to rule out the hypothesis that the “order effect” (A+N<N+A) observed in Experiment 1.a was due to visual pop-out effects linked to different picture arrangements, as this kind of visual effects cannot account for the differences between A+N and N+A observed in a reading task.

In addition, the convergence of results between picture naming and reading points to an effect of “order” in a processing stage shared between these two tasks. As only phonological encoding processes are thought to be shared across these two tasks (Roelofs, 2004) as was mentioned in Chapter 2, different encoding processes between A+N and N+A seem to emerge at this level of encoding. To account for the faster production latencies for A+N than for N+A, we suggest several hypotheses. As we mentioned in the introduction of the experiment, the use of numbers as adjectives for the A+N condition is problematic. If numbers are indeed considered as determiners in the syntactic structure of the NP, then it is not surprising that the comparison of a determiner+noun NP will be processed faster than a noun+adjective NP, the latter being more complex. We will deal with this issue in the following experiment.

Concerns with the design of Experiments 1.a and b.

As already discussed for Experiment 1.a, the difference observed between the A+N and N+A conditions might suggest that the extent to which the two word sequences are prepared differs across these two conditions. However, the "order effect" may be due to differences in the frequency of the adjectives or in the frequency of the sequences across the two order conditions. In fact, *deux* (two) and *cinq* (five) are more frequent than *rouge* (red) and *vert* (green): average frequency for: *deux* and *cinq* = 859 and for *rouge and vert* = 115 per millions in the Lexique database. It might be possible that the difference in RTs is due to this difference in frequency of the adjectives only. It should also be underlined that the adjectives (only 4) were repeated more often than the nouns (48) and that this repetition might have led to an additional frequency effect. Moreover, just as frequencies of single nouns play a role in production speed (Alario, Costa & Caramazza, 2002), frequencies of the entire NP sequence has been reported to affect encoding processes (Arnon & Snider, 2010; Janssen & Barber, 2012). The shorter naming latencies for the A+N condition relative to the N+A condition might be due to a higher frequency of the sequence for A+N which was not matched to N+A in the design of Experiment 1. To rule out whether the "order" effect between A+N and N+A was due to the frequency of the pre-nominal adjectives, the repetition of the adjectives or the frequency of the sequence, we will run a picture naming and a reading task with a better match of all frequencies (lexical and sequences) across A+N and N+A in Experiment 2.a and b and a higher number of adjectives.

III.4 EXPERIMENT 2.a

As in Experiment 1, we manipulated the same kind of syntactic order in 2W NPs (A+N and N+A). To examine whether the order effect could be accounted for by different frequencies across condition, we matched the frequency of the pre-nominal and post-nominal adjectives and the frequency of the sequences across the two 2W conditions. To do so, we looked up every NP sequence in the "French speaking" Google web pages and matched the frequencies of the A+N sequences and N+A sequences as proposed in several studies (Blair et al., 2002; Keller & Lapata, 2003; Janssen & Barber, 2012). In addition, as the length of the noun did not affect the results in experiments 1.a and b, we decided to manipulate the length of the adjective. To keep the same design as Experiment 1, we also added a single noun condition. Moreover, we added more adjectives to ensure that there would be fewer repetitions of the adjectives compared to the repetition of the nouns. If the order effect between the two 2W-NPs conditions remains despite a better control of the frequencies (frequency of the sequence and frequency of the adjective) and a higher number of adjectives, then we can argue that shorter RTs for NPs with a pre-nominal adjective reflect different encoding processes than NPs with a post-nominal adjective. However, if the order effect disappears with a better match of the frequencies, then the differences in encoding between A+N and N+A may have been due to the material of Experiment 1.

Method

Participants

Twenty one French speaking undergraduate students from the University of Geneva took part in the experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Materials

We first selected 28 monosyllabic feminine nouns and their corresponding pictures from two French databases (Alario & Ferrand, 1999 and Bonin, Méot, Aubert, Malardier, Niedenthal & Capelle-Toczek, 2003). The nouns had a mean frequency of 31 occurences per million (SD: 32). We then created 112 two-word NP sequences composed of 4 pre-nominal or 4 post-nominal imageable adjectives giving rise to 56 A+N and 56 N+A sequences ("order condition").

Two adjectives in each order condition were monosyllabic: *cinq,* five, *grosse*, big, *rouge*, red, *noire*, black, giving rise to disyllabic A+N and N+A sequences (short) and the other four were disyllabic , (*ancienne*, old, *nouvelle,* new, *demie*, half, *petite,* small), generating tri-syllabic sequences. The frequency of the pre-nominal and post-nominal adjectives was matched as close as possible (pre-nominal: 190.68 (SD: 101) and post-nominal: 126.08 (SD: 57) occurrences per million words in the Lexique database (New, Pallier, Ferrand, & Matos, 2001). In addition, the initial phonemes of the noun (N) and the adjective (A) were matched on sonority in order to avoid differences across conditions due to voice key measurements. Finally, the frequencies of the entire sequences were taken from the Google search engine (Blair et al., 2002). Those were matched as close as possible across the two order conditions ($p > .16$), but a complete match across short and long sequences was not possible (see Table 4): the frequency of the sequence for short sequences did not differ across NP condition ($p < .12$) but it did differ for long sequences ($p < .03$). Importantly, none of the sequences had a frequency of zero. Four training stimuli were inserted before each block with one sequence from each condition represented. This allowed the experimenter to verify that the participants named each condition as expected. Examples of the stimuli are presented in Figure 7.a and b. The list of the adjectives and their frequency is presented in Appendix 3 and the list of stimuli with the frequency of each NP sequence in Appendix 4.

Table 4

Conditions and Mean Frequency of the NP Sequences with Standard Deviations in Brackets

	Short (2 syllables)		**Long (3 syllables)**	
NP condition	A+N	N+A	A+N	N+A
Frequency of the sequence	1842 (4188)	3475 (5413)	5104 (13037)	244 (505)

Note: the frequency of the sequence measured in hits by using the Google search engine.

Procedure

Before the experiment, participants were familiarized with all the pictures and their corresponding names on a paper sheet. Stimulus presentation was controlled by the DMDX software (Forster & Forster, 2003). The stimuli appeared on a computer screen and participants were instructed to name them aloud as quickly and as accurately as possible. Before the presentation of each stimulus, a fixation cross stayed on the screen for 500 ms followed. The stimulus appeared 200 ms after and remained on the screen for 3000 ms. A blank screen followed and stayed for 2000 ms before the next trial. The experiment lasted about twenty minutes with one break included. The experiment was divided in four blocks of sixty three stimuli each. Within each block the trials were in a different pseudo-randomized order for each subject. Naming latencies of the noun phrases were measured by means of a voice key. Reaction times were measured starting from the onset of the picture to the beginning of the naming response. The experiment started with a training session including fillers for each condition and two extra fillers at the beginning of each block.

Since the design of the experiment was fairly complicated with eight different adjectives to learn, we decided to have the experiment in two parts. In part 1, the participants would learn only four adjectives and their representation. A break would follow at which they were told to call the experimenter. The experimenter would then give them the instructions for part number 2 with the four other adjectives. The stimuli of each part were pseudo-randomized and the two parts were counter-balanced. By using this method, we guaranteed a fairly low number of errors despite a fairly high number of conditions.

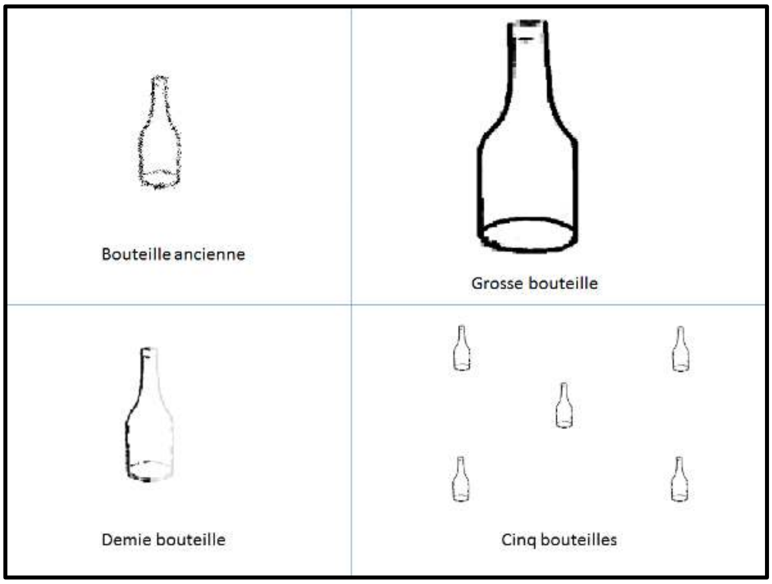

Figure 7.a. Example of the stimuli presented in one part of Experiment 2.a.

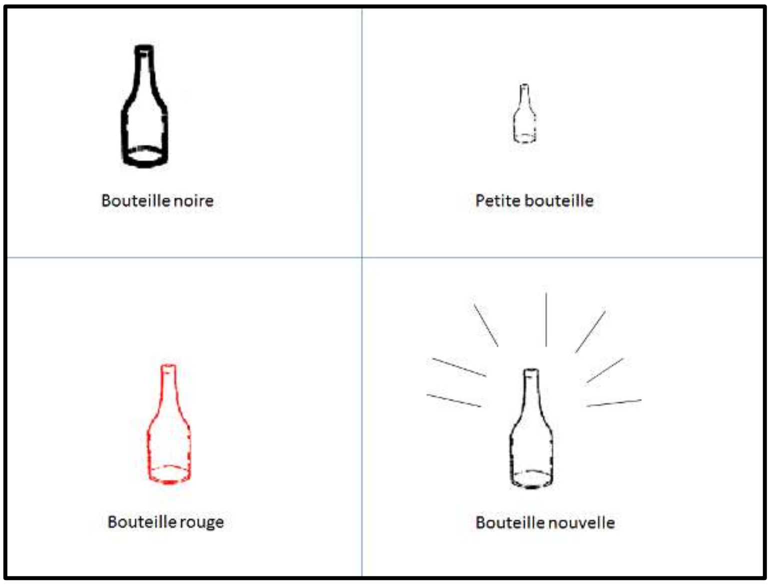

Figure 7.b. Example of the stimuli presented in the other part of Experiment 2.a.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses and technical errors were discarded from the analysis and reaction times above 1700 and below 400 ms were withdrawn from the data analysis. A total of 11.7% of the data was therefore removed (10,45% errors and 1,25% outliers). Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007).

The analysis was done in two steps.

First, we analyzed RTs across the 3 NP conditions[20]. The NP condition (N, A+N, N+A,) was included in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with the same random- and fixed-effects factors. We controlled by-participants and by-items random adjustments to intercepts.

Results are presented in Table 5. Mean RTs are 684 ms for N, 803 ms for A+N and 958 ms for N+A. The main effect is significant: $F(2, 2573) = 85.308$ $p<.0001$). Contrasts indicate that spoken latencies for the N condition are faster than both 2W conditions (N-A+N: $t(2573) = -6.34$ $p<.0001$; N-N+A: $t(2573) = 12.74$ $p<.0001$. In addition, naming latencies for the A+N condition are 153 ms faster than the N+A condition (A+N-N+A: $t(2573) = 7.85$ $p<.0001$).

[20] Contrary to experiment 1.a and 1.b. we did not include the phonological length with the order condition in the first model because this time the length of the adjective was manipulated and not the length of the noun. Therefore we could not test this variable across the three order levels. It was, however, included in the second model.

Error rate showed a difference between N and A+N: z=-2.51, $p<0.0121$), a difference between N and N+A: z=4.01, $p<.0001$ but no difference between A+N and N+A (z<1).

Table 5

Mean Naming Latencies for the Three Conditions of Noun Phrases (ms).

	Mean (SD)	***Error (%)***		
			Order effect	**Difference (ms)**
N	684 (139)	1	N-A+N	120
A+N	804 (177)	4	N-N+A	273
N+A	957 (204)	5	A+N-N+A	153

Note: numbers in brackets are Standard Deviation for each average

In a second model, we included the two 2W conditions (order condition) together with the following fixed effect variables linked to those conditions: the frequency of the sequence, the length of the adjective, the frequency of the adjective. Since the distribution of the frequency of the sequence did not follow a normal distribution, we applied a log transformation to the frequency of the sequence. All these variables were included in a backward-stepwise regression analysis. Since predictors of a multiple regression are likely to be correlated, we first assessed the relation between the frequency of the sequence and the frequency of the adjective with a Pearson correlation test. There was no correlation between the two variables (r =0.11, $p < .28$). We therefore included the two variables as such. The variables for which the coefficient did not reach significance (with a *p* value inferior to 0.05) were discarded from the original model in a step-by-step fashion. The final model included only the variables for which the coefficient reached significance. The following non-significant interactions were removed from the model: the interaction of the order with the frequency of the adjective and the interaction of the order with the frequency of the sequence. Results of the remaining significant coefficients are reported in Table 6 while the overview of the fixed effect for each order condition can be seen in Figure 8 (with A: The order condition, B, The frequency of the adjective and C, The interaction between the order condition and the length of the adjective). Contrasts of the interaction of the order condition with the length condition show that the effect of the length of the adjective is significant for N+A: (t(930) = -4.88, $p < .0001$ but not A+N (t<1).

Table 6

*Regression Coefficients (**β**) with the **t** and **p** Values for Each of the Fixed Effect Predictors in the Regression Analyses of Experiment 2.a*

Predictors	***B***	**Std. Error t**	**t(2051)**	***p*(MCMC)**
(Intercept)	6.553575	0.034019	192.65	.00001
Order	0.15555	0.026318	5.91	.00001
Frequency of the adjective	0.03527	0.005136	6.87	.00001
Length of the adjective	-0.116812	0.028581	-4.09	.00001
Order * length of the adjective	0.099009	0.045925	2.16	.0312

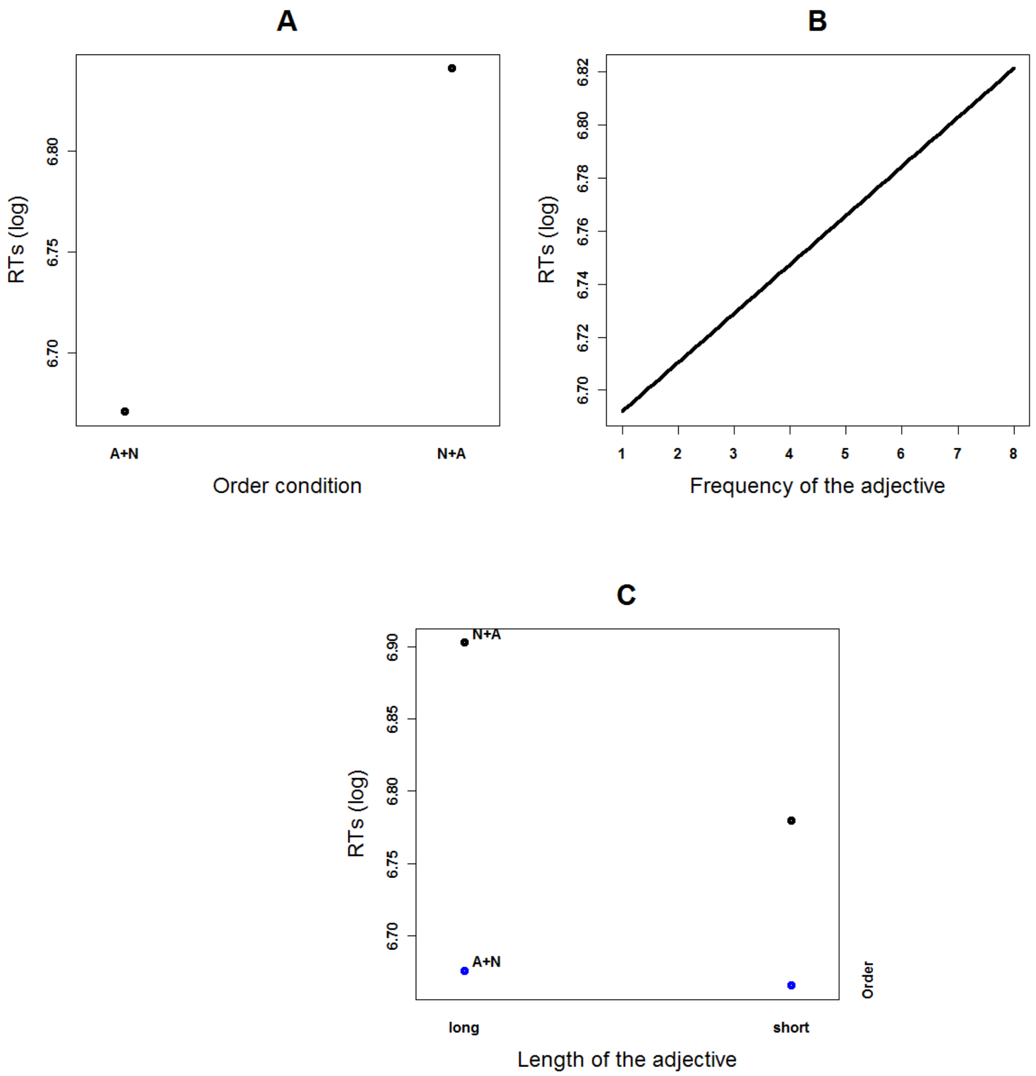

Figure 8. Overview of the effects of the fixed effect variables for experiment 2.a. Figure A represents the order effect with shorter naming latencies for A+N relative to N+A. Figure B illustrates the effect of the frequency of the adjective: the eight adjectives are represented by digits from 1 to 8 (1 corresponding to the least frequent and 8 to the most frequent) with longer naming latencies for highly frequent adjectives. Figure C represents the effect of the length of the adjective for each order condition with decreasing latencies for sequences with short adjectives.

DISCUSSION

First, we replicate the NP condition difference with shorter naming latencies for 1W relative to 2W. Then, we also replicate the order condition effect with shorter naming latencies for A+N relative to N+A. Furthermore, we observe an effect of the frequency of the adjective but with longer naming latencies for highly frequent adjectives. Finally, we observe an effect of the length of the adjective in interaction with the order condition. Contrasts reveal that the N+A condition bears the effect of phonological length.

NP condition

Results for the NP condition of Experiment 2.a are very similar to those of Experiment 1. Again, it seems that encoding of two words NPs extends the initial word. However, as for Exp. 1, visual effects might interfere with speech encoding processes due to the visual complexity of the pictures. We will verify this hypothesis in a following experiment (2.b).

Order condition

Several paradigm-related problems were raised in Experiment 1 in relation to the “order” effect. We suggested that the order effect might have been due to differences in frequencies of the adjectives, or more repetition of the adjectives relative to the nouns, or differences in the frequencies of the sequence across order conditions. With a better match of the frequency of the adjectives and the frequency of the sequence, the order effect remains and cannot therefore be accounted for by unbalanced frequencies from the material.

Effect of the frequency of the sequence

Contrary to Janssen and Barber (2012), we do not observe an effect of the frequency of the sequence. This result is not unexpected as the frequency of the sequence was balanced across conditions (A+N and N+A) and the range of frequencies tested here might have been too narrow to be a significant effect.

Length effect

Even though we report an interaction of the phonological length of the adjective with the order condition, we can see from Figure 8, C. that the effect of length follows the same pattern for both the A+N and N+A condition with shorter NPs produced faster than longer NPs. A significant length effect converges with most models of speech production which argue for a sequential and serial ordering of phonological segments at the phonological encoding level (Levelt, Roelofs, & Meyer, 1999; Levelt & Wheeldon, 1994; Roelofs, 2004). As we mentioned in the introduction, these models predict that the generation of additional segments should delay naming processes in picture naming task. These results seem to be additional evidence to this prediction. Nevertheless, from the review of the literature, we also mentioned that the length effect was inconsistent. We concluded by proposing that the fact that only few authors reported a length effect was maybe because this effect was subject to speakers strategies (Griffin, 2003) and therefore great variability. The suggestion that speakers develop inter-individual strategies in an experimental paradigm will be addressed in Chapter 4. If the length effect is subject to great variability, it might be easier to observe when the compared stimuli differ a lot in terms of syllabic length (1 to 3 syllables) or when the shortest stimuli are already “long” (2 syllables) compared to the long one (3 syllables) as in the current experiment. This would explain why we only report it in Experiment 2 and not Experiment 1.The length effect will be further investigated in Experiment 2.b.

Effect of the frequency of the adjectives

Even though we added more adjectives in this experiment relative to Experiment 1, we report a frequency effect of the adjectives. While frequency effects usually decrease naming latencies (Oldfield & Wingfield, 1965), we observe a reverse pattern in this experiment. We suggest that the frequency effect of the adjectives is due to the fact that only few adjectives were used and therefore repeated for this experiment.

Concerns with the design of Experiment 2.a

Two major points need to be taken into account for the following experiments.

First, to explain the fact that the order effect remains despite a complete control of the material, we suggest the following: the adjective we selected for the A+N condition (*cinq*, *demi*, *grosse*, *petite*) were all adjectives which are either strictly pre-nominal or "prefer" a pre-nominal position in French (Thuilier, 2012). On the other side, the adjectives selected for the N+A condition were either strictly post-nominal (*rouge*, *noire*) or could be used as both pre-nominal or post-nominal position (*ancienne*, *nouvelle*). However, even though we used them as post-nominal adjectives, the last two are usually used as pre-nominal adjectives in French (Thuilier, 2012). What affected naming latencies in N+A might actually have been the preferred position of the adjective. This suggestion will be tested in Experiment 3.

Second, before we investigate the preferred position of the adjective, we have to rule out the fact that results from Experiment 2.a are not due to the design of the experiment. The design of this experiment was fairly complex as it is difficult to select pictures that generate adjective-noun phrases with eight adjectives and control for frequencies across conditions as well. Most picture naming tasks in psycholinguistics use in average 2-to-4 different adjectives (mostly colors adjectives) due to imageability constraints. The fact that we tested eight different adjectives might have created an extra cognitive load, which could explain these results. Furthermore, visual effects due to the complexity of the images might have led to different strategies from the participants in order to be more efficient. Therefore, we cannot rule out that this effect is due to the material selected and not to an actual length effect. This issue will be examined in Experiment 2.b in a reading task with the same stimuli used in Experiment 2.a.

III.5 EXPERIMENT 2.b

Experiment 2.b was a reading task using the exact same stimuli as in Experiment 2.a. If similar results are observed in the reading task, then we can infer that the results obtained in Experiment 2.a are not due to the cognitive load created by the extra adjectives or the visual complexity of the images.

Method

Participants

Twenty six French speaking undergraduate students from the University of Geneva took part in the experiment. This time, all of them had participated in the picture naming task. They received course credit for their participation. All had normal or corrected-to-normal vision.

Material

We used the exact same stimuli as in Experiment 2.a in a reading task. The sequences were shown in Arial Narrow 16.

Procedure

Stimulus presentation was controlled by the DMDX software (Forster & Forster, 2003). The stimuli appeared on a computer screen and participants were instructed to read them aloud as quickly and as accurately as possible. Before the presentation of each stimulus, a fixation cross stayed on the screen for 500 ms followed. The stimulus appeared 200 ms after and remained on the screen for 800 ms. A blank screen would then follow and stay for 500 ms. The experiment lasted about fifteen minutes with three breaks included. Within each block the trials were pseudo-randomized to maximize distance between similar stimuli. Naming latencies of the noun phrases were measured by means of a voice key. Reaction times were measured starting from the onset of the stimulus to the beginning of the naming response. The experiment started with a training session with two stimuli.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical errors were discarded from the analysis and reaction times above 1037 and below 271 ms were withdrawn from the data analysis. A total of 2.5% of the data was therefore removed (2.1% of errors and 0.4 % outliers). Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors. We controlled by-participants and by-items random adjustments to intercepts. Results can be observed in Table 7. As for Experiment 2.a, the model was done in two steps.

First we analyzed the NP condition.

Mean reaction times are 488 ms for N, 532 for A+N, 567 for N+A. The NP condition was first analyzed: N is 44 ms shorter than A+N being the shortest 2W condition. The main effect of condition is confirmed: ($F(1, 2840) = 67.48$ $p<.0001$). Contrasts across conditions were analysed. Again, spoken latencies for the N condition are faster than all the other conditions (N vs. A+N: $t(2840) = -6.56$ $p<.0001$; N-N+A: $t(2840) = -11.52$, $p<.0001$. Naming latencies for the A+N condition are 35 ms faster than the N+A condition (A+N vs. N+A: $t(2840) = -6.09$ $p<.0001$).

Error rate showe no difference between N and A+N ($z<1$), but a difference between N and N+A ($z= -2.15$, $p<0.031$) and a difference between A+N and N+A ($z=-2.83$, $p<.004$).

Table 7

Mean Naming Latencies for the Three Conditions of Noun Phrases (ms).

	Mean (SD)	***Error (%)***	**Order effect**	**Difference (ms)**
N	488 (86)	0,03%	N-A+N	44
A+N	532 (99)	0,36%	N-N+A	79
N+A	567 (110)	1,62%	A+N-N+A	35

Note: numbers in brackets are Standard Deviation for each average

As for Experiment 2.a, we included the two 2W conditions (order condition) together with the following fixed effect variables linked to those conditions: the frequency of the sequence, the length of the adjective, the frequency of the adjective. The frequency of the sequence was log transformed. All these variables were included in a backward-stepwise regression analysis. The variables for which the coefficient did not reach significance (with a p value inferior to 0.05) were discarded from the original model in a step-by-step fashion. The final model included only the variables for which the coefficient reached significance. The frequency of the sequence and the frequency of the adjective were removed from the final model[21]. Results of the remaining significant coefficients are reported in Table 8 while the overview of the fixed effect can be seen in Figure 9 (with A, The order condition; B, The length of the adjective).

Table 8

*Regression Coefficients (***β***) with the* **t** *and* **p** *Values for Each of the Fixed Effect Predictors in the Regression Analyses of Experiment 2.b.*

Predictors	***B***	**Std. Error t**	**t(2051)**	***p(MCMC)***
(Intercept)	6,29E+03	3,14E+01	200.53	.0000
Order	6,02E+01	1,01E+01	5.93	.0000
Length of the adjective	-3,75E+01	9,98E+00	-3.76	.0002
Frequency of the adjective	-7,86E-02	6,06E-02	-1.30	.194

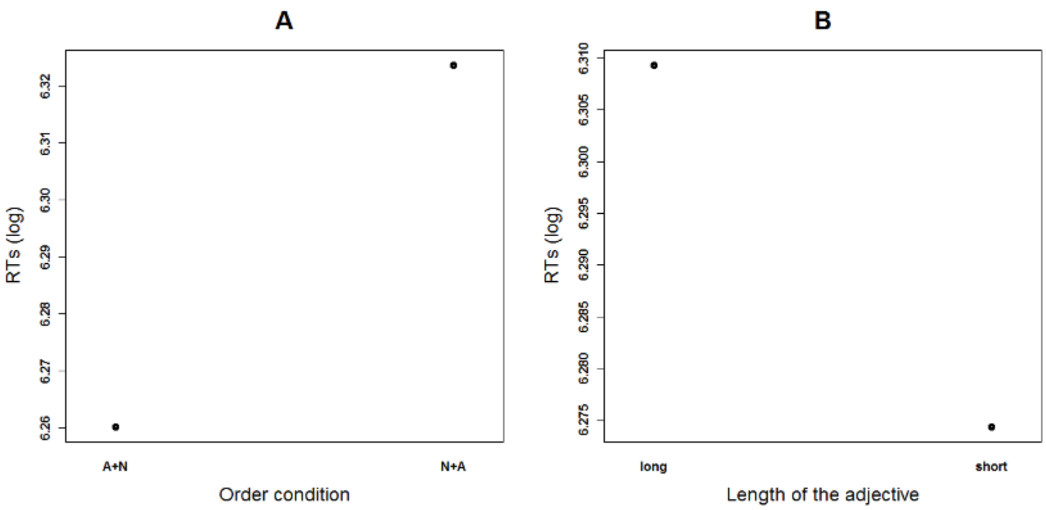

Figure 9. Overview of the effects of the fixed effect variables for experiment 2.b with A, the mean reaction times for each order condition and B, the mean reaction times for the length (short and long) condition .

DISCUSSION

Experiment 2.b was run as a control experiment of Experiment 2.a to test whether the order effect might be due to a heavy visual-cognitive load. Four major results are observed.

[21] The values of the frequency of the adjective are reported are they are above >1 for t.

NP condition

First, we replicate the order effect in the NP condition with shorter RTs for the single N condition and shorter RTs for the A+N condition relative to the N+A condition. The fact that we observe shorter naming latencies for N relative to the two 2W conditions suggest that encoding of one word in a reading task is less costly than encoding of two words. This might be due to the presentation of two items (words) versus one item in which case the longer reaction times for the 2W condition simply comes from the fact that the system has to deal with more visual information. However, the fact that this effect is replicated in the picture naming task where both 1W and 2W conditions are elicited by only one picture suggest that results from Exp. 2.b might simply mean that encoding of NPs in a reading task extends beyond the initial word.

Order condition

Then we observe an effect of order with shorter naming latencies for the A+N condition relative to the N+A condition. The fact that the order effect between A+N and N+A is still observed in a reading task suggests that the order effect reported in Experiment 2.a is not due to visual processes.

Frequency of the sequence

As for experiment 2.a, the frequency of the sequence did not affect reading times.

Frequency of the adjectives

We do not report a frequency effect of the adjectives in the reading which suggests that the frequency effect reported in the naming task might be an artifact due to the material. Taken together, the inhibitory effect of the frequency of the adjectives in Experiment 2.a (naming) and the non-significant in Experiment 2.b (reading) seem to suggest that the number of adjectives selected in Experiment 2 was too low. Experiment 3 will investigate whether the repetition of the eight adjectives might account for this result.

Length effect

As for the naming task in Experiment 2.a, we replicate an effect of the length of the adjective. The fact that it is consistent across the two experiments in our study suggests along with other parallel results that similar phonological processes are involved during naming a picture and reading a word (as proposed by Roelofs, 2004). However, we need to mention that some studies comparing picture naming and reading tasks in the literature reported an effect of length for reading only but not naming (Bates et al., 2001).

Concerns with the design of Experiment 2.a and b.

Experiment 1 and 2 presented an order effect for which several issues were raised but also ruled out. However, the design of these experiments still presents a weakness as the nouns and adjectives are not entirely balanced. In all these experiments, more nouns than adjectives were used. The adjectives were therefore repeated more often than the nouns. As the A+N condition starts with an adjective, the shorter naming latencies for this condition might be explained by the fact that adjectives were used more frequently within the task. Moreover, the position of the adjectives in N+A sequences was not always entirely appropriate. The following experiment will therefore examine these two issues. Experiment 3 will use the exact same nouns and adjectives in different syntactic orders and will investigate whether the preferred position of the adjective might explain the order effect obtained in the previous experiments.

III.6 EXPERIMENT 3

The purpose of Experiment 3 was to examine the “order effect” with a material completely balanced across A+N and N+A sequences. We selected exactly the same adjectives and nouns and the same number of adjectives and nouns in each condition and matched the frequency of the sequence across conditions. For this purpose, we created NPs with adjectives which could be used both in a pre-nominal or post-nominal position. This was only possible in a reading task. If the order effect reported in the previous experiments with shorter naming latencies for A+N relative to N+A was due to the repetition or the frequency of the adjectives then we should no longer observe an order effect with a material perfectly balanced across conditions. Importantly, we also investigated whether the preferred position of the adjective within the adjective-noun phrase could be a predictor of naming latencies.

Method

Participants

Twenty one French speaking undergraduate students took part in the experiment. All of them had participated in the picture naming task. They received course credit for their participation. All had normal or corrected-to-normal vision.

Material

36 nouns with frequencies ranging from 2.06 to 696.4 occurrences per million (average: 115.2, SD: 117.08) and as many adjectives with frequencies ranging from 9.13 to 400.32 occurrences per million (average: 87.96, SD:95.95) were selected. The selected 36 adjectives could be both pre-nominal and post-nominal. Each adjective was associated to a noun in each of the two conditions: A+N (*immense voiture*) and N+A (*voiture immense*).
The frequency of the sequences was calculated with the same method as in experiments 2.a and b: mean frequency of the sequence for A+N = 473.6, SD: 2174; for N+A = 28.19, SD: 101.1 ($p < .16$). Note that all sequences were plausible as their frequency was > 1. The list of the stimuli is presented in Appendix 5. In order to prevent participants from noticing that each NP was also used in its reverse order, we introduced twice as many fillers: half of them were A+N sequences and the other half N+A sequences. The preferred position of the adjective will be introduced in the discussion in a post hoc analysis.

Procedure

Stimulus presentation was controlled by the DMDX software (Forster & Forster, 2003). The stimuli appeared on a computer screen and participants were instructed to read them aloud as quickly and as accurately as possible. Before the presentation of each stimulus, a fixation cross stayed on the screen for 500 ms followed. The stimulus appeared after 200 ms and remained on the screen for 800 ms. A blank screen would then follow and stay for 500 ms. The written stimuli were displayed in Arial bold 14. The experiment lasted about fifteen minutes with one break half way. Within each block the trials were pseudo-randomized to maximize distance between similar stimuli. Naming latencies of the NPs were measured by means of a voice key. Reaction times were measured starting from the onset of the sequence to the beginning of the naming response. The experiment started with a training session with four stimuli.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical errors were discarded from the analysis and reaction times above 960 and below 290 ms were withdrawn from the data analysis. A total of 3% of the data was therefore removed (2% of errors and 1% of outliers). Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). We controlled by-participants and by-items random adjustments to intercepts. We included the order variable and the frequency of the adjectives in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors. Mean naming latencies are presented in Table 9, results of the significant coefficients in Table 10 and the overview of the effect of the frequency of the adjective in Figure 10.

Error rate showed no difference between N+A and A+N (z<1).

Table 9

Mean naming latencies (ms) and error rates (%) for the two conditions of Noun Phrases.

Order condition	***Mean (SD)***	***Error (%)***
A+N	500 (60)	2
N+A	517 (61)	2

Note: numbers in brackets are Standard Deviation for each average

Results of the remaining significant coefficients are reported in Table 9 while the overview of the fixed effect can be seen in Figure 10. The order effect was significant, so was the frequency of the adjective. There was no significant interaction.

Table 10

*Regression Coefficients (*β*) with the* **t** *and* **p** *Values for Each of the Fixed Effect Predictors in the Regression Analyses of Experiment 3.*

Predictors	***B***	**Std. Error t**	**t(2051)**	***p(MCMC)***
(Intercept)	6.219e+00	2.041e-02	304.74	.0000
NP condition	3.505e-02	1.230e-02	2.85	.0044
Frequency of the adjective	-1.952e-04	6.416e-05	-3.04	.0024

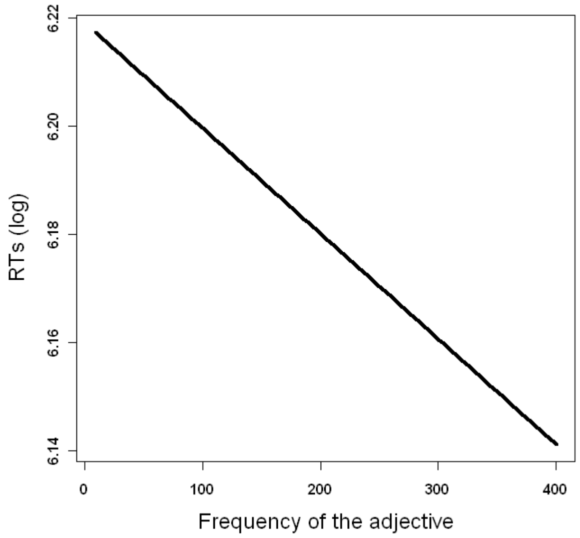

Figure 10. Overview of the effects of the frequency of the adjective in Experiment 3.

DISCUSSION

The purpose of this experiment was to verify whether the order effect with shorter naming latencies for A+N relative to N+A reported for Experiment 1 and 2 was due to the repetition of the adjectives or the frequency of the adjective and thus the fact that A+N sequences start with a more frequent element than N+A sequences. We therefore selected a material perfectly balanced in terms of frequencies of the different elements of the NPs (similar A and N across each order condition) and we also balanced the frequency of the entire sequence of the NP. Despite this perfect match, the order effect and the frequency effect of the adjective remain suggesting different encoding processes for the two different types of NPs. Before discussing these results further, we need to investigate whether the order effect might be due to the preferred position of the adjective with a post hoc analysis.

Post hoc analyses on the preferred position of adjective within the NP

To verify whether the preferred position of the adjective might explain the shorter naming latencies for A+N relative to N+A, we estimated two different values of the preferred position of the adjective. The first value (a coefficient) corresponds to the absolute estimation of the preferred position of the adjective and the second value (a ratio) corresponds to the relative estimation of the preferred position of the adjective. First, we analyze which of the two estimations is the best predictor of naming latencies in the production of adjective-noun phrases. As we report a null effect with both estimations, we push the investigation further by predicting that the preferred position of the adjective accounts for the order effect and we test this hypothesis (alternative hypothesis).

1. a. Absolute preferred position of the adjective

The absolute estimation of the preferred position of the adjective is based on the results obtained in the corpus study by Thuilier (2012) which deals with the position of attributive adjectives in French. As not all the adjectives we used in Experiment 3 are reported in this corpus study, we estimated the preferred position of the adjective for a subset of 48 NPs from the original 72 NPs dataset. The list of the 48 NPs is reported in Appendix 6.

Method

The preferred position of the adjective is estimated using the French Treebank corpus (Abeillé & Barrier 2004, Abeillé et al. 2003). To estimate the likelihood of the preferred position of an adjective within a NP in context, Thuilier (2012) used mixed-effects logistic regression models. The models included adjectival lemmas as random effects on the intercept. The variable to predict is the pre-position of the adjective within the NP. Ten explicative variables were included in the models to see which variable best predicts the behaviour of the variable "pre-position of the adjective".

The ten variables take different constraint types into account:

- Syntactic constraints

  -whether the adjective is in coordination or not
- Lexical properties:

  -whether the adjective is derived or not,

  -whether the adjective is associated with a pre-modifying adverb or not,

  -whether it is a nationality or not,

-whether it is indefinite or not[22]

- Cognitive processing constraints

  -phonological length of the adjective,

  -phonological length of the adjective-noun phrase

  -frequency of the adjective
- Collocationnal effect of the noun in pre-position or post-position[23]

The probability of an adjective to be pre-nominal is estimated as a function of these 10 variables. The model predicts post-position if the probability is below 0.5, and pre-position if it is higher or equal to 0.5. We use this value comprised between 0 and 1 as the predictive variable in the following analysis.

Material

The list of the different estimations for each NP is reported in Appendix 6. Figure 11 clearly shows that a higher rate of adjectives from this subset of 48 NPs prefer to be pre-nominal. This observation could easily account for the shorter naming latencies for A+N relative to N+A.

[22] For these variables a boolean value was used (true or false).
[23] For these variables *real* numbers were used.

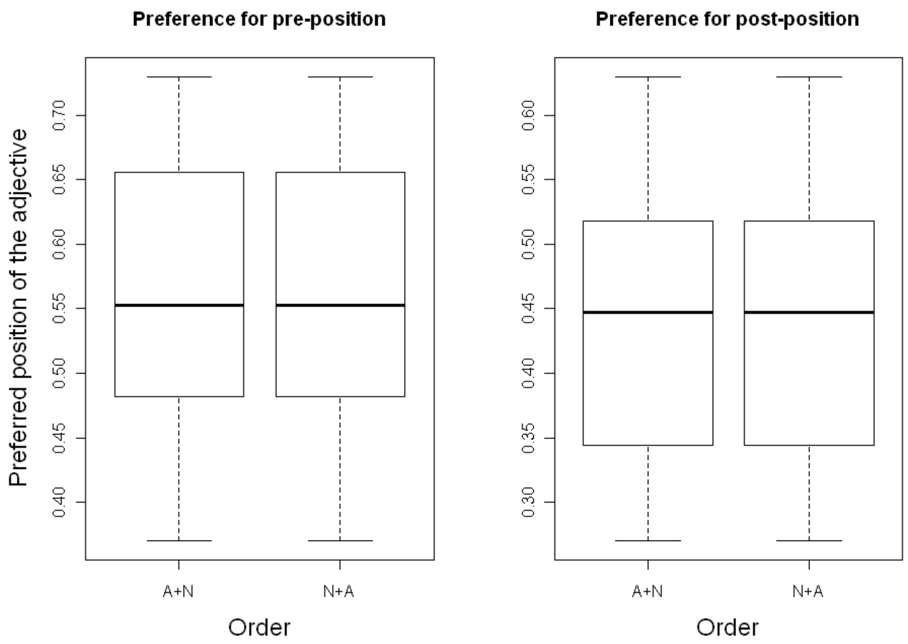

Figure 11. Estimated preferred position for a subset of 24 NPs from Experiment 3. On the y-axis is the coefficient for the preferred position of the adjective. The left plot represent the mean coefficient for the adjectives with a preference for pre-position while the right plot represents the mean coefficient for the adjectives with a preference for post position.

Results

We tested this hypothesis with a generalized mixed model with the order condition and the estimated preferred position of the adjective as a continuous fixed effect variable and participants and items as random effect variables. The order effect remains significant (t(930) = 2.15, $p < 0.32$). We also observe a marginal effect of the absolute estimated preferred position of the adjective (t(930) = -1.95, $p = .051$). These results suggest that even though the preferred position of the adjective seems to be a predictor of naming latencies, it does not account for the order effect as the order effect remains when the absolute preferred position of the adjective is included in the model.

1. b. Relative preferred position of the adjective

As the preferred position of the adjective seems to be a predictor of naming latencies in the subset of Experiment 3 but fails to account for the order effect, we propose an alternative post hoc analysis to the previous one with two different approaches.

First, we estimate the preferred position of the adjective based on its association with a specific noun within the NP. The reason for this estimation is that the semantic relationship between a noun and an adjective differs depending on the position of the adjective within the NP (cf. Chapter 1). The interaction between the semantic association of a different element composing a NP with the position of the adjective can therefore be relevant [24] when investigating the influence of the preferred position of the adjective within a NP. An additional argument comes from a corpus based study from Fox & Thuilier (2012) where the authors attempt to model the prediction of the position of an adjective within a NP (as in Thuilier, 2012, section 1.a). After investigating the different constraints mentioned in the previous section (1.a), the authors conclude that the determining constraints in the ordering of the adjective are information specific to the adjective-noun phrase itself and its context of use (language processing), but not constraints based on a more general and abstract level. In which case, the language processing system might be more sensitive to a relative estimation of the preferred position of the adjective with a specific noun than an absolute one.

Method

We estimate the position preference ratio of a NP as its likelihood to have an adjective in a specific position. For a given noun and a given adjective, two combinations only are possible (A+N and N+A) to create an adjective-noun phrase[25]. Therefore the sum of likelihoods for the two combinations must be equal to 1. The likelihood L for a NP is calculated as the absolute frequency F of that NP divided by the sum of the absolute frequencies of that NP and the opposite combination:

$$\boldsymbol{L}(A+N) = \frac{\boldsymbol{F}(A+N)}{\boldsymbol{F}(A+N) + \boldsymbol{F}(N+A)}$$

$$\boldsymbol{L}(N+A) = \frac{\boldsymbol{F}(N+A)}{\boldsymbol{F}(A+N) + \boldsymbol{F}(N+A)}$$

If a given NP has a position preference ratio close to 1, it means that having the given adjective in that position is highly favoured in combination with the given noun. The opposite position must be close to 0 and is therefore highly unfavoured.

For example, for the two opposite sequences *immense voiture* and *voiture immense*:

[24] It is to note that note all authors agree on the fact that the semantic association of the noun with the adjective is a predictor of the position of the adjective as we mentioned in Chapter 1 (p20).

[25] This is valid for the material of Experiment 3 as the adjectives selected can be both pre- and post-nominal.

Position preference ratio with the adjective in pre-position (A+N): 243/(243+328) = 0.426

Position preference ratio with the adjective in post-position (N+A): 328/(243+328) = 0.574

This example shows that the adjective *immense* is easily used in both positions when associated with the noun *voiture*. However, for the adjective *brave* associated with *dame* in the NP *brave dame*, the ratio is 0.997 (close to 1), which means that when associated with *dame*, the adjective *brave* strongly "prefers" pre-position.

Material

The list of the stimuli with the position preference ratio is presented in Appendix 5. Similarly to section 1.b, we can observe in Figure 12 that the estimated position preference ratios for the A+N condition is clearly favoured with a higher rate of adjectives positioned in their preferred position.

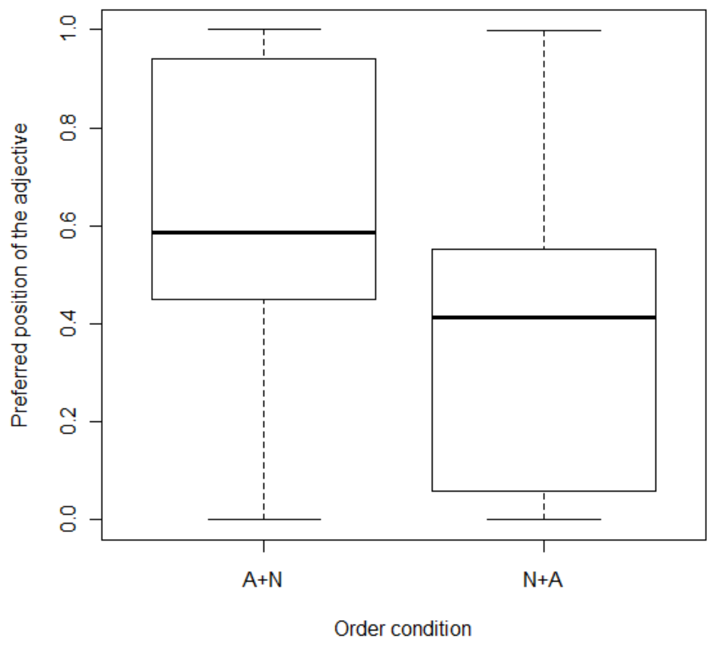

Figure 12. Preferred position of the adjective within an adjective-noun phrase for each order condition. The preferred position of the adjective (from 0 to 1) is determined by the ratio calculated on the base of the frequency of the sequence and represents the likelihood of an adjective to occur in a specific position when associated with a specific noun. The more likely an adjective is to be in its favorite position, the close to 1 its ratio will be.

This unbalanced distribution of the position preference ratios might explain the shorter naming latencies for the A+N condition (where the preferred condition is mostly or highly favoured) relative to the N+A condition (where the preferred position of the adjective is not favoured). We verified whether the position preference ratio is a better predictor of naming latencies than the absolute estimation of the preferred position of the adjective.

Results

To do so, as for the previous analysis, we used the estimated position preference ratio of the NP as a continuous fixed effect variable together with the order condition in a generalized mixed model. While the order effect remains ($t(1347) = 2.38$, $p < .017$), the position preference ratio does not reach significance ($t<1$). The position preference ratio does not seem to be a better predictor of naming latencies in the production of adjective-noun phrases than the absolute estimation used in section 1.a.

2, Alternative hypothesis

As a null effect can be the result of various reasons, we decided to investigate this null effect further by proposing the following prediction: If the order effect is the result of the preferred position of the adjective within the NP, we predict that the reversed order effect (shorter naming latencies for N+A when the preferred position is respected) should be observed by selecting NPs which prefer post-position. We tested this hypothesis by removing from our dataset all the NPs which clearly favored pre-position in the A+N condition. We only retained the NP sequences for which the preferred position of the adjective was favoured in N+A NPs (ratio above 0.4 for N+A). The list of the subset of 34 stimuli can be observed in Appendix 7. If a favored preferred position of the adjective within the NP accounts for the shorter naming latencies in A+N, then we should expect to obtain either no difference in the order condition or a reversed order effect with shorter naming latencies for N+A. Analyses on this subset show that when selecting adjectives favouring post-position in the N+A condition, the order effect disappears ($t< 1$). The difference between A+N and N+A decreases from 17 ms (original dataset) to 9 ms (this subset) but A+N NPs are still produced faster. Unfortunately, as we do not observe a reversed effect with shorter naming latencies for N+A relative to A+N, we cannot conclude that the preferred position of the adjective accounts for the order effect. We can only suggest that it is a predictor probably correlated with other variables that we have not controlled for.

III.8 General Discussion

The purpose of this first experimental chapter was first to test whether the production of one word differed from the production of two words and more specifically, whether speakers encode more than a single word when they produce 2W NPs. Secondly, we aimed to investigate whether pre-nominal adjective-noun phrases and post-nominal adjective-noun phrases presented similar or different encoding patterns. Different predictors were investigated relative to this question. Table 10 represents an overview of the results of all the experiments presented in this chapter.

Table 10

Overview of the Overall Results for Each Experiment.

	Exp 1.a	**Exp. 1.b**	**Exp. 2.a**	**Exp. 2.b**	**Exp. 3**
Task	PNT	Reading	PNT	Reading	Reading
Variables	NP condition	NP condition	NP condition	NP condition	
	Order condition	Order condition	Order condition	Order condition	Order condition
			Frequency of the sequence	Frequency of the sequence	
			Frequency of the adjective	Frequency of the adjective	Frequency of the adjective
	Length (N)	Length (N)	Length (A)	Length (A)	
					Pref. position adj

Note: the Variables in Light Grey are the significant variables ($p < .05$).

Importantly, the similarity of the observed effects across tasks allows us to suggest that picture naming and word reading share similar encoding processes and that the results from Experiment 3 (reading task only) are reliable enough to draw conclusions on the encoding processes involved in the production of NPs.

NP condition

The first result we want to underline is that single words were produced faster than the 2W NPs (both A+N and N+A) in all the experiments (Experiments 1.a and b and 2.a and b). This reliable effect in all tasks strongly suggests that more than the first word is encoded in adjective-noun phrases. Even though this chapter does not allow to investigate explicitly how far the second word is encoded, the different results reported in this chapter allow to infer how much is planned ahead before speaking in the production of French adjective-noun phrases.

Order condition

As Table 10 shows, the order effect is reported for all the experiments independently of the paradigm (picture naming or reading). It is therefore a robust effect and might suggest that different encoding patterns are involved in the production of A+N and N+A NPs. However, the fact that naming latencies are always shorter for the A+N condition relative to the N+A condition raises several problems. First, we mentioned in the introduction that some cross-linguistics studies propose a larger span of encoding for A+N relative to N+A NPs (Schriefers & Teruel, 1999a) as encoding might be determined by the smallest full syntactic phrase (A+N in A+N and N in N+A). However, this does not seem to be the case with these results as we observe shorter latencies for A+N sequences relative to N+A sequence. To be in agreement with Schriefers and Teruel´s hypothesis (1999a), we should have reported longer latencies for the A+N condition relative to N+A. Second, an additional argument in favor of a larger span of encoding in A+N sequences in French is that this kind of sequences may require obligatory liaison (cf p 11) while N+A sequences do not. More planning ahead is therefore suggested for A+N for the speaker to produce a correct liaison sequence. Again, if this hypothesis holds, we should observe longer, or at least similar naming latencies for A+N relative to N+A (these hypotheses will be directly investigated in Chapter 4). We therefore investigated whether shorter naming latencies for A+N relative to N+A could be accounted for by different frequencies across conditions but this suggestion was discarded in Experiment 2 and Experiment 3 where the frequencies of the adjectives were completely matched across conditions. This allowed to rule out any potential frequency difference between the two order conditions.

Frequency of the sequence

Frequencies of the sequences were also matched as close as possible but as a perfect match was not possible, we decided to verify whether this variable affected naming latencies and could account for the shorter production latencies for A+N relative to N+A. Despite a better match of the frequencies, the order effect persisted. Contrary to Janssen & Barber (2012) who did report an effect of the frequency of the sequence for N+A NPs in French, we did not observe such an effect (neither in naming nor in reading). Nevertheless, the range of frequencies of the sequence tested here might have been too narrow to show significance.

Preferred position of the adjective

Material from Experiment 2 and 3 used adjectives for which the preferred position was not completely respected. However, as we wanted to use pictorial stimuli (Experiment 2) and perfectly balanced lexical frequencies of the NP to be named across conditions (Experiment 3), the choice of adjectives was quite limited. In Experiment 3, we estimated two different values to predict the preferred position of the adjective within the NP. One value was an absolute estimation and the other value was a relative estimation of the preferred position of the adjective. We demonstrated that the A+N NPs from this material was clearly composed of NPs for which the preferred position of the adjectives was respected (preference for pre-position) while N+A NPs presented the opposite pattern. We therefore investigated whether the preferred position of the adjectives could account for the order effect reported in all experiments. However, we failed to show that the preferred position of the adjective was a significant predictor of naming latencies.

Frequency of the adjective

We mentioned in Chapter 1 that the preferred position of the adjective is strongly correlated with the frequency of the adjectives (Wilmet, 1980). Highly frequent adjectives are usually pre-nominal. If the preferred position of the adjective does not predict naming latencies in the production of French NPs, the frequency of the adjectives might. We tested this hypothesis in Experiment 2 where the frequency of the adjectives was manipulated with more adjectives. We did observe an effect of the frequency of the adjectives (although inhibitory) and we also reported an order effect again with shorter naming latencies for A+N relative to N+A. As the adjectives were still fewer than nouns, their repetitions might have led to an additive frequency effect. This could account for the shorter naming latencies for A+N relative to N+A as they start with the most frequent element. We tested this hypothesis in Experiment 3 where all the frequencies of the components of each NP were perfectly balanced with the same nouns and adjectives in reversed order. The order effect remained and the effect of the frequency as well with no interaction. As it is not the result of the preferred position of the adjective, we propose the following: even though we matched the frequency of the adjectives with the frequencies of the nouns, they may differ on a different manipulation of frequency, namely the relative frequency within the grammatical class as there are fewer adjectives than nouns in the lexicon. If relative frequency counts, the frequency of the adjectives is higher than the relative frequency of the nouns despite similar absolute frequencies. Thus, if we consider as Levelt, that only one word is encoded before articulation, A+N sequences should be encoded faster as they start with a more frequent element. This relative frequency of the adjective could account for the order effect.

Nevertheless, this suggestion is in contradiction with the fact that we report a frequency effect of the adjective in N+A. The effect of the frequency of the adjective for both conditions in Exp. 2.a and 3 suggests indeed that the entire N+A sequence is encoded at some level before articulation. This is in line with the fact that longer naming latencies are reported for N+A relative to A+N. To reconcile the result with the suggestion according to which one word only is encoded before articulation, we have to consider that the frequency effect is revealing of the span of encoding at the lexical-semantic level. The difference in encoding should therefore find its locus at a post-lexical level. The span of encoding at the lexical-semantic and phonological level will be explicitly investigated in the next chapter.

Length effect

We did not report a length effect in Experiment 1 for the nouns but we did report a length effect for the adjectives in Experiment 2 in both the reading and the naming task. The sequences tested in Experiment 2 were longer as we compared the production of bisyllabic NPs and trisyllabic NPs while Experiment 1 compared the production of monosyllabic NPs to the production of bisyllabic NPs. The length effect might be better detected for stimuli of a "minimum" length which would explain why the length effect was only reported in Experiment 2. An alternative explanation for the fact that we obtain a length effect for the adjectives, but not for the nouns, could come from the link between the preferred position of the adjective within the NP and its phonological length. Different linguistic studies previously described the link between the placement of a lexical element and its phonological length.

This phenomenon, which is not restricted to adjectives (Stallings, MacDonalds & O'Seaghdha, 1998; Wasow, 2002; Hawkins, 2001; Bybee & Mcclelland, 2001), is sometimes referred to as *heaviness* or *end-weight* (Quirk, Randolph, Sidney, Greenbaum, Geoffrey, Leech & Jan Svartvik, 1972). It is the observation that long and complex constituents are more likely to be placed at the end of a phrase. The purpose of placing the shortest element before the dominating constituent is to better process the phrase (adjectival phrase, verbal phrase etc.) and ease processing of the overall message. This linguistic account is actually also in line with Griffin´ suggestion (cf. p46) according to which length can be used as a strategic clue to plan ahead in speech production.

Conclusion

The main result reported in this chapter is the fact that we report longer naming and reading latencies for two words versus one word. Encoding processes in the production of 2W NPs seem to extend the initial word before articulation. However, the results of the current chapter do not allow us to infer how much is precisely encoded in the production of adjective-noun phrases.

The second important result is that different encoding processes seem to be involved in the production of French adjective-noun phrases whether the adjective is pre-nominal or post-nominal. The major difference we reported was the shorter naming latencies for A+N relative to N+A. To explain this order effect, we will propose three different accounts based on the different theories and models we reviewed in the literature.

1. Corpus-based studies on order constraints

Of all the predictors investigated, none of them could account for the order effect autonomously. However, it seems clear that most of these predictors are correlated with the position of the adjectives. These predictors, which favour pre-position of an adjective within the NP (high frequency, short phonological length and strong semantic cohesion), are also predictors which are reported to ease cognitive processing during speech production. It would therefore be likely that A+N NPs are produced faster although the span of encoding is the same as in N+A NPs. Additional evidence for this claim comes from the fact that A+N NPs are the eldest adjective-noun phrase structure (Glatigny, 1967; Wilmet, 1981; Bybee, 2009) while N+A is more recent and is the structure attributed to the new adjectives (Thuilier, 2012). To make it clearer, we can consider the principle of least effort (Zipf, 1949) which stipulates that any unnecessary change in language in particular (and human behavior in general) will be removed or avoided. According to this principle, language evolution will be achieved by selecting the most proficient and straightforward way to communicate. A+N sequences being older structures should therefore be the result of an evolution under the law of the least effort and be less cognitively costly than a more recent structure (N+A). This suggestion is limited as it is in contradiction with the fact that post-nominal adjectives developed as the most frequent structure though.

2. Universality of word ordering

Universal ordering of words can account for easier processing for A+N and N+A. Generative Grammar stipulates that the A+N structure is the universal (deep) structure (Kayne, 1994) and that the N+A structure is the result of the N rising above the A in a syntactic representation (surface structure). Taken together, these arguments suggest that A+N structures are likely to be less flexible than N+A structures and do not allow changes. This canonicity of the A+N NP might suggest that this structure is cognitively easier to process as it is encoded in a straightforward fashion (with no movement).

3. Psycholinguistic account

Experimental results indicated longer naming latencies for 1W relative to 2W and a frequency effect of the adjective in both A+N and N+A. Taken together, these results suggest encoding beyond the initial word at a level which we argue is the lexical-semantic level. The reason for suggesting a longer span of encoding at this stage and not at a post-lexical stage is because we also have to account for the shorter latencies for A+N relative to N+A. If we follow Levelt´s argument according to which only one phonological word is entirely encoded before articulation the message, this means that in the production of A+N, the first element encoded is the adjective while in the case of N+A, the first element of the noun is encoded. When we compared the production of the two sequences, we matched the frequency of the noun and the adjectives perfectly in Experiment 3 and yet A+N sequences were produced faster and a frequency effect of the adjective was reported. We suggest that this is due to the relative (intra-class) frequency of the adjectives which are less numerous than nouns and therefore repeated more often. As claimed by Bell, Brenier, Gregory, Girand and Jurafsky (2009) in a study the predictability effects on duration of content and function words in connected speech, "*frequent words present shorter durations and a variety of other lenited characteristics such as reduced vowels, deleted codas, more tapping and palatalization, and reduced pitch range*

(Fidelholz, 1975; Hooper, 1976; Rhodes, 1992, 1996; Bybee, 2000; Fosler-Lussier & Morgan,1999; Pluymaekers, Ernestus, & Baayen, 2005; Aylett & Turk, 2006; Munson, 2007)". Therefore, if the system is sensitive to the frequency of the first element, this may explain why sequences starting with an adjective were produced faster than those starting with a noun.

Even though these three accounts differ in their interpretation of the results, they are not incompatible. If the system processes completely one word only before articulation (3rd account) at some encoding level, it does not exclude the fact that the frequency of the sequence as a whole (1st and 2nd account) is being processed at another level. Overall, our interpretation of these results actually suggests a larger span of encoding at the lexical-semantic level relative to the span of encoding at the phonological level. The following chapter will focus on the span of encoding in the production of two-word NPs with a picture naming task and a priming paradigm. This will allow us to obtain more precise information on how much is encoded by a speaker before articulating and at the same time verify the 3rd account, namely, whether the phonological word is the minimal unit of encoding as stipulated by Levelt.

Chapter 4: The investigation of the span of phonological encoding in a picture naming task with semantic and phonological priming

IV.1 Introduction

This chapter investigates the amount of ahead planning for the production of pre-nominal and post-nominal adjective-noun phrases in the light of the psycholinguistic literature. In the previous chapter, we compared the production of two different types of NPs (A+N) and (N+A) and concluded that the two sequences presented differences in encoding processes. Differences in the span of ahead planning in the production of NPs have also been reported in the literature as we underlined in Chapter 2: while many experimental studies suggest that the entire NP is encoded before articulation, other results favour a span of encoding limited to the first word. Although cross-linguistic differences in the structure of adjective-noun phrases may account for some of these contrasting results, divergences have been reported even among similar languages and syntactic structures. As a reminder, studies investigating Romance languages such as French (Schriefers & Teruel, 1999a, Dumay et al., 1999; Damian et al, submitted) and Italian (Miozzo & Caramazza, 1999) do not find a priming effect beyond the initial word of a NP. Only one study by Costa and Caramazza (2002) reports a priming effect for the second word in Spanish. While studies on English and German (Damian & Dumay, 2007, 2009, Schnur et al, 2006, Schnur, 2011; Oppermann et al., 2010) very often report a span of encoding comprising the entire message, from simple NPs to verbal sentences, only one study by Schriefers and Teruel (1999) failed to report an effect on N in A+N sequences in German. Based on these observations, we expect the minimal unit of encoding to be different between A+N and N+A NPs in French.

Two new dimensions will be integrated in the following study. First, we examine ahead planning in NPs in French, including the structure which has usually been investigated in Romance languages (N+A sequences), but also A+N sequences, which have not been investigated previously in a Romance language. Second, we explore inter-individual variability linked to production speed. Several studies (Wagner et al., 2010; Gillespie & Pearlmutter, 2011) indeed suggested that speakers use different strategies when producing speech. If cross-linguistic differences alone cannot account for the diverging results from the literature, this hypothesis might be an alternative explanation. The following experiments will use a picture naming task (PNT) as in Chapter 3, but this time coupled with a priming paradigm. As we mentioned in Chapter 2, priming paradigms are a very convenient method to investigate the span of encoding at the different encoding levels (semantic/syntactic and phonological). We created five experiments based on some of the studies that we have just described. The first experiment (Experiment 1) investigated the span of encoding of adjectival

NPs at the lexical (semantic priming) and at the phonological level (phonological priming). In this experiment only the noun (N) was primed. At the lexical level, we obtained an interference effect for the priming condition compared to the neutral condition for the N in both positions (A+N and N+A). At the phonological level, we observed a facilitation effect only for the N in initial position. Even though these data seem to indicate that encoding is larger at the lexical level than at the phonological level in French NPs as suggested in the previous chapter, the interpretation cannot be complete without testing 1, all the elements of the NPs and 2, at various SOAs. Therefore, we decided to run the same experiment and prime not only the nouns but also the adjectives of the NPs at the phonological encoding level. In the following set of experiments (Experiment 2.a, b and c), all targets were phonologically primed by primes of the same grammatical categories. Nouns were always primed by nouns and adjectives by adjectives. Moreover, we decided to run this same experiment at three different SOAs (-150 ms, 0 ms, +150 ms) to see whether the type of SOA chosen influences the outcome of the results. Results from Experiment 2 show that phonological priming effects are limited to the first word in adjective NPs whichever the position of the adjective (pre-nominal or post-nominal) and the SOA selected. Crucially, phonological priming effects on the second word interacted with participants´ production speed which suggests different encoding strategies according to speed. In Experiment 3, we tested this hypothesis further with a larger group of participants. Results clearly show that slow and fast initialising participants presented different phonological priming patterns on the last element of adjective-noun phrases: while the first word was primed by a phonologically related word for all speakers, only the slow speaker group presented a priming effect on the second element of the NP.

IV.2 EXPERIMENT 1

In this experiment, we investigated production latencies of two different types of two-word French NPs in a picture naming task with semantic and phonological distractors. We used same syntactic units (a noun: N and an adjective: A) in two different syntactic orders: one with a pre-nominal adjective A+N (*grand chat*) and one with a post-nominal adjective N+A (*chat rouge*) to have the noun in initial and final position.

If we observe longer naming latencies for the noun in either position with semantic distractors compared to the neutral condition, then we can infer that the entire NP is encoded at the lexical level as in Meyer (1996) and Costa and Caramazza (2002). Similarly if we observe a facilitation effect for the priming condition compared to the neutral condition at the phonological level in both order conditions (A+N and N+A), it suggests that the entire sequence is encoded at the phonological level too. Moreover, this "mirror" structure allows us to determine whether priming effect differs when different lexical targets (adjective and noun) are primed.

Method

Participants

Thirty students from Neuchatel University took part in the experiment. All had normal or corrected-to-normal vision.

Material

In order to create forty adjectival NPs, we selected twenty nouns and their corresponding pictures and four adjectives. The preferred position of the adjective within the NP was respected in the material and the selected adjectives were either strictly pre-nominal or post-nominal (Thuilier, 2012). All pictures represented bi-syllabic masculine nouns (see characteristics in Appendix 8). Four adjectives were selected. For the condition where the noun was the first element of the noun phrase (N+A condition), *rouge* (red) and *vert* (green) were chosen while *grand* (big) and *vieux* (old) were selected to make the A+N condition. All nouns appeared in each order condition but inside each order condition, half of the nouns appeared with one of the two adjectives while the other half appeared with the other adjective. In order to match the frequency of the pre-nominal and post-nominal adjectives and the frequency of the sequences across the two order conditions (A+N and N+A), we applied the method proposed by Blair et al. (2002) based on Google counts. We looked up every NP sequence in the "French speaking" Google web pages and selected which noun should be matched with which adjective in order to obtain similar frequencies for the A+N sequences and N+A sequences (See Appendix 8). In this experiment, the sequences were only composed of the adjective and the noun without determiners. Semantic distractors were from the same semantic category. They were not associative and none of them were "part-whole distractors" (i.e. a distractor word which is a part of the target word such as *wheels* as a distractor word for *car* as a target word) to avoid facilitation effects instead of interference effect as reported in the literature (cf. section about semantic priming p32). Phonological distractors all shared at least the first syllable of the target while semantic distractors only shared no more than one phoneme with the target. Phonological and semantic distractors were all disyllabic nouns.

Distractors for the unrelated condition were all disyllabic. They were not related semantically and did not share any phonemes with the target words. A list of the target words and their distractors are presented in Appendix 8. All distractors were presented auditorilly to make sure that a possible effect obtained was not reflecting effects from potential visual processes as mentioned in Oppermann et al. (2010). Moreover they were presented at SOA 0 which seems to be the most appropriate SOA to be selected for this type of priming paradigm according to the results reported in the literature. For example, *balai* (broom) was primed by *torchon* (cloth) at the semantic level, by *ballon* (balloon) at the phonological level and by *commode* (drawer) in the unrelated condition (see Table 11).

Table 11

Example of Primes for A+N Sequences: Vieux balai

Target stimulus	**Semantic distractors**	**Phonological distractors**	**Unrelated distractors**
Balai (broom)	Torchon (cloth)	Ballon (balloon)	Commode (drawer)

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical RT errors were discarded from the analysis and reaction times above 1950 and below 550 ms were withdrawn from the data analysis. The data of two participants were removed due a high percentage of errors. A total of 9% of the data was therefore removed.

Results are displayed in Table 12. Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). The order condition (A+N, N+A) and distractor (unrelated, phonologically related and semantically related) were included in a generalized mixed model as fixed effect variables and participants and items as random effect variables. We controlled by-participants and by-items random adjustments to intercepts. We analysed the order condition and the priming condition separately. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors.

First, we observe a significant difference across the two order conditions: A+N sequences are initiated 96 ms faster than N+A sequences: $F(2,3006)=157.1$; $p < .001$.

Then, a main effect of priming is observed: $F(2, 3006)=3.407$; $p < .03$. Contrasts indicate that there is a significant semantic interference effect as compared to the unrelated condition for the A+N condition relative to the neutral condition: (t(3006)= 3.05; p< .01) and a marginal effect for the N+A= (t(3006)= 1.7; *p*< .08). Phonological facilitation compared to the neutral condition is observed only for the N+A sequences: (t(3006)= 3.72; *p*< .001) but not for A+N: (t<1). The error rate is higher in the semantically related condition than in the neutral condition (z = -4.107, *P*= 0.0001). There is no difference for the phonologically related condition relative to the neutral condition (z<1) and no difference in the order condition either (z<1).

Table 12

Mean RTs and SD for the Three Conditions of Noun Phrases (ms).

	Mean SD		***Difference in ms***		***Error (%)***	
Condition	**A+N**	**N+A**	**A+N**	**N+A**	**A+N**	**N+A**
Semantically related	899 (155)	1010 (203)	23	17	15	12
Unrelated	875 (144)	993 (195)			8	7
Phonologically related	881 (148)	951 (169)	-6	42	9	9
Total	885 (152)	985 (189)			5	4

DISCUSSION

Three observations emerge from these results. First, the significant semantic interference effect for the noun in each order condition seems to indicate that each sequence is entirely encoded at the lemma level at least for the A+N condition. Even though these results do not allow us to draw the same conclusion for N+A, we recall that the effect of the frequency of the adjective reported for N+A in Exp. 2 and 3 (Chapter 3) suggested a span of encoding comprising the entire N+A sequence at an encoding level which we suggest is the lexical level. Taken together, these results suggest that the entire NP is encoded at the lexico-semantic level. Second, the phonological facilitation effect being observed only in the N+A condition suggests that only the first element of the sequence is encoded phonologically before the speakers start articulating. Third, sequences where the noun is the second element of the NP are produced faster than sequences where the noun is the first element which is in line with results reported in the previous chapter. In sum, results from this first experiment indicate a span of encoding larger at the lexical level than at the phonological level. These results are in line with those presented by Meyer (1996), even though the stimuli tested were different (adjectival noun phrases versus word pairs). By contrast, these results are not congruent with some other results from the literature which reported phonological priming effects on the second element of the NP (Costa & Caramazza, 2002; Alario & Caramazza, 2002; Miozzo & Caramazza, 1999; Schnur et al, 2006, 2011, Oppermann et al., 2010).

However, in Experiment 1, only the noun was tested. Therefore, it is maybe too early to draw conclusions on the span of encoding in N+A condition at the phonological level. To go further with these results, we created Experiment 2 for which both the nouns and the adjectives were primed in each position. In addition, since Jescheniak et al. (2001) observed a difference[26] between the production of bare nouns and nouns with determiners, we added determiners to the NP sequences of Experiment 2. This was done in order to make sure that the lack of effect of the noun in A+N sequences was not due to the absence of determiner and also to have sequences which were closer to spontaneous speech.

IV.3 EXPERIMENT 2.a

This experiment is based on the same material as the previous experiment. However, we only focused on the phonological encoding level with phonological distractors priming both the nouns and the adjectives.

If the first word of French NPs only is encoded at the phonological level as reported in previous studies, then we should observe a facilitation effect for both the noun and the adjective being in the first position (in N+A and A+N respectively) and no effect when being in the second position. By contrast, if previous cross-linguistic differences were due to the structure of adjectival NPs, then we should observe differences between the two types of NPs with a larger encoding level for A+N relative to N+A.

[26] It is to note that this difference was a decrease of the effect of the noun in simple NPs relative to bare nouns. However, as reported in the literature, some expected facilitation effects can turn inhibitory and vice versa so we might expect to obtain an effect on the second noun of the NP by adding a determiner.

Method

Participants

Thirty French-speaking undergraduate students took part in the experiment. They received course credit for their participation.

Material

The material was the same as in Experiment 1 with the addition of phonologically related distractors to the adjectives. Each noun and each adjective was associated with a phonological and an unrelated distractor from the same grammatical category. In order to reduce repetitions, two primes were selected for each adjective in each condition. Phonologically related primes shared the onset and at least an extra phoneme with the target adjectives. So for instance *vieux* (old) was primed once by *vide* (empty) and once by *vil* (vile) for the phonologically related condition while it was primed once by *chaud* (hot) and once by *doux* (soft) in the unrelated condition. The distractors were presented auditorily.

Procedure

Before the experiment, participants were familiarized with all the pictures and their corresponding nouns and adjectives on a paper sheet. The stimuli appeared on a computer screen and participants were instructed to name them aloud with the corresponding NP as quickly and as accurately as possible and to ignore the words they heard in the headphones. A short training session with filler items preceded the experimental session and was repeated if necessary until the subjects felt confident about the instructions. Stimulus presentation was controlled by the DMDX software (Forster & Forster, 2003). Each trial had the following structure: fixation cross stayed on the screen for 500 ms, followed by a 200 ms blank screen, then the stimulus (the picture) appeared on the screen at the same time as the distractor word played in the headphones (at SOA 0). The picture remained on the screen for 3000 ms. A blank screen followed and stayed for 2000 ms before the next trial.

Each picture appeared four times (once in each condition, i.e. phonologically related or unrelated prime to the adjective or to the noun). The order of presentation of the stimuli was pseudo-randomized in four blocks so that each picture appeared once in each block and blocks were counter-balanced across participants. There was a pause between the two blocks. Production latencies (RTs) were measured starting from the onset of the picture to the onset of the vocal response.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical errors were discarded from the analysis and outliers (reaction times above 1700 and below 400 ms) were withdrawn from the data analysis. A total of 14% of the RTs was removed. The results are presented in Table 13.

Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates and Sarkar, 2007). We analysed separately two datasets according to the position of the element related to the prime: the first elements, whether it was the adjectives or the noun (W1 priming) and the second elements (W2 priming). The syntactic order (A+N, N+A) and distractors (unrelated, phonologically related) were included in a generalized mixed model as a fixed effect variables and participants and items as random effect variables. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors.

We controlled by-participants and by-items random adjustments to intercepts.

For W1 priming, the facilitation effect of the distractor condition is significant ($t(2052)=2.08$; $p< .037$) without interaction between priming and syntactic order ($t<1$). We also observe an effect of the syntactic order condition ($t(2052)=12.99$; $p< .0001$) on RTs, A+N sequences being produced faster than N+A sequences. The error rate does not differ between the phonologically related condition and the neutral condition ($z<1$) for the W1 priming nor for the order condition ($z<1$).

For W2 priming, there is no effect of the distractor: ($t<1$) and no interaction between priming and syntactic order ($t<1$). The only significant effect observed is the syntactic order effect ($t(2052)=8.29$; $p<0.0001$), with shorter latencies for A+N than for N+A.

The error rate analysis does not differ across conditions (all $zs<1$).

Table 13

Mean RTs in ms (SD in brackets) and Error Rate for Each Condition

	MeanSD		***Difference (ms)***	***Error (%)***	
Word1 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
A+N	774 (168)	787 (175)	13	1.5	1.8
N+A	855 (203)	871 (209)	16	1.8	1.7
Word 2 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
A+**N**	798 (177)	807 (192)	9	1.7	1.7
N+**A**	860 (196)	852 (193)	-8	1.7	1.9

DISCUSSION

Results from Experiment 2.a suggest that phonological priming effects are limited to the first word of adjective-noun phrases, whether it is an adjective or a noun. These results seem to indicate that only the first element of the NP is encoded at the phonological level no matter the syntactical status or the order of the constituents. Overall, these findings are in line with previous results reporting phonological priming limited to the first word of the sentence (Meyer, 1996; Miozzo & Caramazza, 1999; Schriefers & Teruel, 1999a and 1999b, Damian et al, (Experiment 2, submitted) but not with those reporting a larger encoding span (Schnur et al., 2006, Schnur, 2011 and Costa & Caramazza, 2002). In particular, the present results are congruent with previous studies on post-nominal adjective NPs reporting an effect of priming limited to the N in French (Schriefers & Teruel, 1999a; Dumay et al., 2009, Damian et al., submitted). By contrast, the lack of phonological priming effects on the second word in A+N sequences is in contradiction with several previous studies reporting a priming effect on N although in other languages (Costa & Caramazza, 2002, in English; Dumay et al., 2009 in English).

Along with the arguments in favour of the encoding up to the N in pre-nominal adjective-noun phrases outlined in the literature, the lack of significant priming effect on the 2nd word may be due to the following reasons. First, distractors appearing at SOA 0 may be an efficient prime only for the first word of the sequence but be too early to prime the second word of the NP (Jescheniak et al.'s, 2003). We will test this hypothesis in Experiment 2.b by shifting the primes to SOA +150. Second, as suggested by Wagner et al., (2010) and Ferreira and Swets, (2002) speakers might use different encoding strategies, in particular in experimental tasks.

Post hoc analyses on the subject inter-individual differences

1. Post hoc analyses were conducted on the data of Experiment 2.a to analyse whether failure to obtain a priming effect on the second element in Experiment 2.a might be due to inter-individual differences. We split the group of participants into two sub-groups according to their naming latencies (average latencies for the "fast" speaker group: 745 ms and 900 ms for the "slow" speaker group) and tested the interaction of the priming effect with the speed of initialisation. An interaction between speed and priming condition was observed for priming of the noun in A+N sequences: ($t(996) = -6.05$, $p < .0001$. The phonological priming effect was 8 ms in the faster subgroup and 12 ms in slower subgroups although contrasts do not reach significance ($ts < 1$). The interaction between priming of the second word and speed in N+A sequences was also significant ($t(984) = -3.96$, $p < .0001$) with a -33 ms priming effect for the slow subgroup ($t(488) = -2.32$, $p < .021$) and 9 ms effect for the fast subgroup but no effect of the contrasts appeared for the fast group ($t < 1$). Thus, an interaction between the priming effect and speed of initialisation is observed for all NPs; but contrasts fail to emerge. Failure to reach significance for the contrasts is likely to be due to a lack of statistical power since only 15 participants were considered in each speed sub-group.

2. To address this issue, we displayed the data of all participants in a so-called *delta plot* (de Jong, Liang & Lauber, 1994). *Delta plots* belong to the category of quantile-quantile plot (often called Q-Q plots). Q-Q plots allow the comparison of two probability distributions. This comparison is effectuated by plotting the quantiles of one condition (i.e. phonologically related condition) against the quantiles of another condition (i.e. phonologically unrelated condition) and determine whether the two populations present a common distribution or not. *Delta plots* allow to focus on differences in population by displaying the effect of one variable as a function of the

distribution of the response latencies. In the current experiment, *delta plots* will allow us to display the phonological priming effect as a function of the distribution of the naming latencies of all the participants (and not sub-groups as in the previous post hoc analysis). *Delta plots* are expected to display the phonological priming effect as a positive slope as this effect is facilitatory. If, as we would like to argue, encoding of W2 (but not W1) is subject to variability as a function of speakers´ naming latencies, we should observe a change of the effect across time in the *delta plot* for W2 but not W1. Figure 13 displays the priming effect for W1 and W2 at SOA 0 ms respectively. The slope for the priming of W1 is positive and does not change as a function of speakers´ naming latencies. The effect is consistent for all types of speakers. Contrastively, priming of W2 presents a different pattern. While fast naming latencies (between 650 ms until approximately 800 ms after picture presentation) for the priming of W2 do not reveal a facilitation effect, a positive slope increases together with longer naming latencies (between approximately 800 to 950 ms after picture presentation). This figure clearly shows that the effect varies as a function of speakers' naming latencies for priming of the second element of the NP only but that no variation if observed for W1 priming.

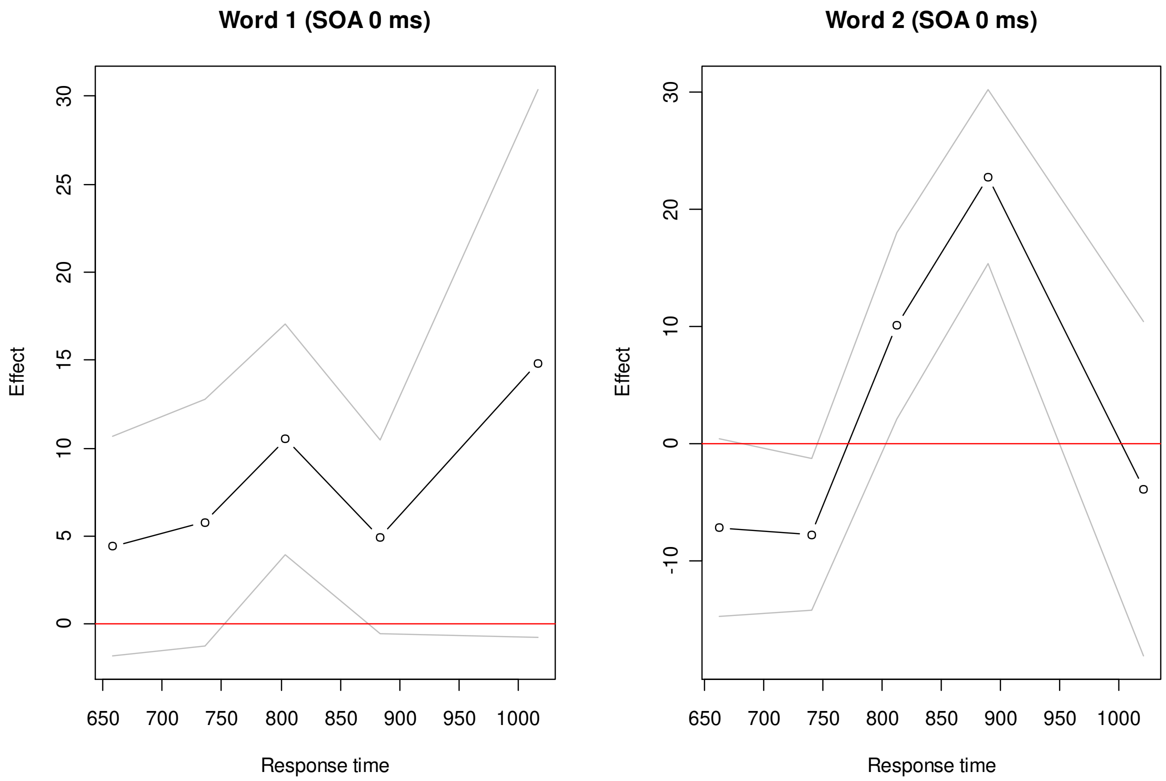

Figure 13. Delta plots for the priming effect (phonologically related or unrelated) of the first word of the NP and the second word of the NP respectively at a neutral SOA. On the x-axis is the distribution of naming latencies. On the y-axis is the size of the effect (positive values represent the facilitation effect while negative values represent an inhibitory effect). The distribution of the RTs is averaged per quantile (here 5 quantiles represented by the circles on the plot) and participants.

These post hoc analyses suggest that speakers encoding of the second word varies across naming latencies. The hypothesis of between-subject differences in ahead planning will be further investigated with a larger group of participants in Experiment 3. But before addressing this question explicitly, we will verify whether different SOAs might be more relevant in this PNT.

IV.4 EXPERIMENT 2. b

Experiment 2.b was the exact same experiment as Experiments 2.a but with phonological distractors appearing at SOA +150 ms. Shifting the SOA to a later time window may allow the facilitation effect on the second word to arise. This suggestion is based on Jescheniak et al.'s (2003) graded activation account. In this account, the authors suggest that the earliest element of the utterance will receive the highest activation while the others' will decrease.

Elements outside the scope of phonological encoding will receive no activation and should therefore present no effect whatsoever if primed phonologically. On the contrary, primed elements being in the first position of the utterance and within the scope of phonological planning will show a clear facilitation effect. However, primed elements occurring at a later position in the utterance and being still in the scope of phonological planning will show a decrease of activation or might even present an inhibitory effect. The reason for this is that conflict will occur between the "natural" priming of the initial element of the utterance and the "induced" priming of the latter one. In Experiment 2.b, we take this account into consideration and shift the SOA to a later time window (+150 ms). If the scope of encoding is limited to W1 only, then we should observe no priming effect on W2 even when shifting the SOA to a later time window. However, if the scope of planning extends W1, then we should observe an inhibitory effect for W2 since induced priming of W2 will compete with natural priming of W1.

If the priming effect of the second element in Experiment 2.a failed to arise because of too early an SOA, then we should observe a priming effect for all the elements of the NPs for this experiment (strong facilitation effect for W1 and inhibitory effect for W2).

Method

Participants

Twenty French speaking undergraduate students took part in the experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Material

The material was the same as in Experiment 2.a.

Procedure

The procedure was exactly the same as in Experiment 2.a except that auditory distractors appeared 150 ms after picture onset (SOA +150).

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical errors were discarded from the analysis and reaction times above 1960 and below 350 ms were withdrawn from the data analysis. A total of 11% of the RTs was removed.

Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates and Sarkar, 2007). As in Experiment 2.a we analysed separately the data where the first or the second word were primed the syntactic order condition (A+N, N+A) and distractor condition (unrelated, phonologically related) were included in a generalized mixed model as a fixed effect variables and participants and items as random effect variables. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors. We controlled by-participants and by-items random adjustments to intercepts. Results are presented in Table 14.

For the W1 priming condition we observe an interaction between distractor and syntactic order ($t(1386)= 1.96$, $p< .049$) no main effect of priming ($t>1$) and an effect of the syntactic order condition ($t(1386)=8.41$; $p< .0001$) with A+N sequences being faster than N+A sequences. Contrasts on the effect of priming for each syntactic structure fail to reach significance (A+N ($t(670)=-1.12$, $p=.26$) and N+A ($t=(670)=1.62$, $p=.10$).

There is no significant effects on error rate (all zs<1).

For W2 priming only the syntactic order condition yields a significant effect on RTs ($t(1386)=5.13$; $p< .0001$, all other ts<1). No effect of conditions on error rate is observed (all z<1).

Table 14

Mean RTs and SD for Each Condition at SOA +150 (in ms)

	MeanSD		***Difference (ms)***	***Error (%)***	
Word1 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
<u>A</u>+N	804 (268)	787 (251)	-17	1.1	0.8
<u>N</u>+A	864 (288)	870 (275)	6	0.9	0.9
Word 2 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
A+**<u>N</u>**	825 (262)	814 (265)	-11	0.9	1.1
N+**<u>A</u>**	882 (308)	876 (275)	-6	0.9	1

DISCUSSION

Experiment 2.b was run to verify whether shifting the SOA at a later time window might lead to a priming effect on the second words of the NPs. First, priming effects observed on the first word of the sequences in Exp. 2.a disappear at SOA +150. A possible explanation is that the SOA chosen might have been too late. It is indeed difficult to determine the best time window. Second, contrary to what predicted, we do not observe a priming effect on W2 in the NPs when distractors are moved to SOA+150. Nevertheless, even though we do not report a significant effect on the second word of the NP, it is interesting to see that, as predicted by Jescheniak et al´s (2003), priming on the second word with a positive SOA follows an inhibitory pattern. As for Experiment 2.a, we displayed the data in a *delta plot* (Figure 14) to determine whether the phonological priming effect was modulated as a function of naming latencies. First, in agreement with the results, the graphical distribution presents a very negative slope for W2 priming. Second, Figure 14 clearly shows that failure to observe a facilitation effect is constant across time when distractors are displayed at a positive SOA (+150 ms). This suggests that the choice of a positive SOA is not adequate for investigating subject variability as a function of their naming latencies.

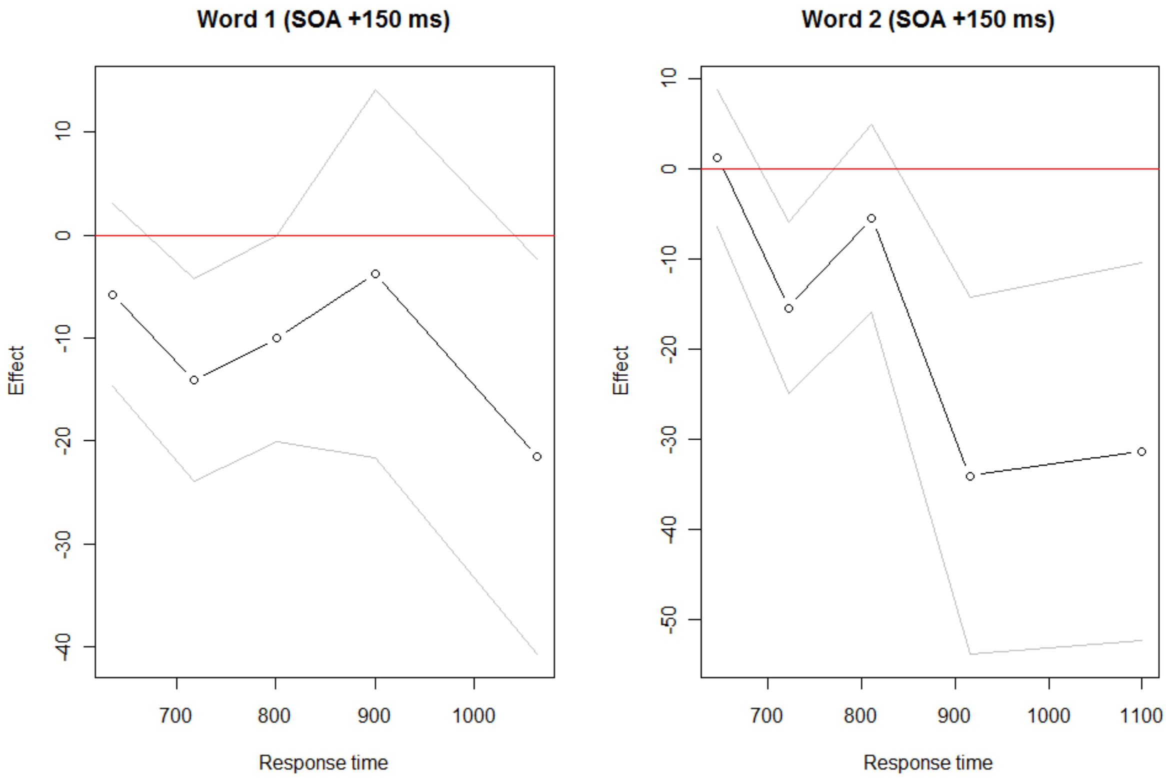

Figure 14. Delta plots for the priming effect (phonologically related or unrelated) of the first word of the NP and the second word of the NP respectively at a positive SOA (+150 ms). On the x-axis is the distribution of reaction times. On the y-axis is the size of the effect (positive values represent the facilitation effect while negative values represent an inhibitory effect). The distribution of the RTs is averaged per quantile (here 5 quantiles represented by the circles on the plot) and participants.

Taken together, results from Experiment 2.a and 2.b might suggest that the selection of different SOAs for W1 (SOA 0) and W2 (positive SOA) might be more reliable and would have had allowing priming on W2 to arise. The same type of SOA for words occurring at different times in the message might interfere with encoding processes.

We will now investigate the effect of phonologically related distractors presented at a negative SOA to determine whether an early SOA might be more efficient as it leaves more time for the system to process the distractor.

IV.5 EXPERIMENT 2. c

Experiment 2.c was the exact same experiment as Experiment 2.a and b but with phonological and unrelated distractors appearing at SOA -150 ms. By presenting the primes at an earlier SOA, we expect to replicate the effects obtained in Experiment 1 and Experiment 2. a, namely an order effect and a facilitation effect for the element in the first position of the NP. Furthermore, the fact that the SOA appears earlier might allow the priming effect to be more "efficient" and lead to a facilitation effect of the second element of the NP as well.

Method

Participants

Twenty French speaking undergraduate students from the Geneva University took part in the experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Material

The materiel was the same as in Experiment 2. a and b.

Procedure

The procedure was exactly the same as in Experiment 2.a and b but with distractors appearing at SOA -150 ms.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical RT errors were discarded from the analysis and reaction times above 2040 and below 630 ms were withdrawn from the data analysis. A total of 7% of the RTs was therefore removed.

Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates & Sarkar, 2007). We divided the data into two groups: in the first group were the data where the first elements were primed whether it was the adjectives and the noun (W1) and in the second group were the second elements that were primed (W2). We kept the order condition to be consistent with the design of Experiment 1 and Experiment 2.a and b. The order (A+N, N+A) and distractor (unrelated, phonologically related) were included in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. We controlled by-participants and by-items random adjustments to intercepts. Error rates were fitted with logit mixed-effects models (Jaeger 2008) with same random- and fixed-effects factors. The results are presented in Table 15.

First, for the W1 data, as in Experiment 1 and 2, we observe an effect of the order condition (t(1443)=10.22; $p < .0001$) A+N sequences being initiated faster than N+A sequences (93 ms). Then we can note an interaction between the order condition and the distractor condition (t(1443)=-2.02; $p < .014$). Contrasts indicate an interference effect with longer naming latencies when the distractor is phonologically related to the noun for the N+A condition: t(1443): 2.02; $p < .044$) but no effect for the A+N condition: (t<1). These results only show an interference effect of the noun in the first position but not of the adjective.

As for the W2 data, the only effect observed is the order effect once again (t(1444)=5.08; $p < .0001$). No interaction between the two conditions is observed and no effect of the distractor: (ts<1). A marginal effect of priming is observed on the error rate for the second word (z = -1.88, $p < .06$) but not for the first word (z>1).

Table 15

Mean RTs and SD for Each Condition at SOA -150 (in ms).

	MeanSD		***Difference (ms)***	***Error (%)***	
Word1 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
A+N	982 (208)	998 (198)	16	0.9	1
N+A	1127 (246)	1099 (255)	-28	1	0.6
Word 2 primed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
A+**N**	1022 (230)	1032 (229)	10	1.3	0.8
N+**A**	1097 (261)	1084 (241)	-13	0.9	0.8

DISCUSSION

In this experiment, we expected to replicate a facilitation effect of the first element of the NP and a possible facilitation effect of the second element to arise.

First, we report an order effect once again. However, we not find a facilitation effect for the adjective in the first position (A+N) and we also a rather important interference effect (28 ms) for the noun in the first place (N+A). No effects are observed for the elements in the second position.

How can we explain this unexpected interference effect of the noun in the first position? The first obvious explanation is the choice of SOA. A negative SOA will prime a specific word before the participant even sees the picture. So if the participant hears a specific word (*house* for ex.), a bottom up process will be triggered before the target (*hour* for ex.) appears. Conflict will then occur at the semantic-lexical level when the participant starts the whole naming process of the target word. So this interference effect of N in N+A sequences might come from an upper level (the lexical-semantic level) than the phonological level and be due to the paradigm chosen.

We can also observe that naming latencies of Experiment 2.c (mean: 1055 ms) are much longer than naming latencies of Experiment 2.a (mean 825 ms) and Experiment 2.b (mean: 840 ms). Although different participants were involved in the three experiments, this is an additional cue to help us conclude that the choice of a negative SOA in our experiment leads to more interference rather than reflecting the encoding processes involved in speech production. The *delta plot* representing the effect of phonological priming for W1 and W2 respectively is presented in Figure 15. This graphical display allows to see the interfering effect with a negative SOA relative to the previous experiments (2.a and b) using neutral and positive SOA. While the slope starts by being positive for the fast naming latency quantiles, it quickly turns negative in both W1 and W2 conditions. Taken together, the inhibitory effect of the N in N+A, the lack of facilitation effect on W1 in both A+N and N+A and the unexpected pattern of the priming effect displayed by the *delta plot* suggest that the choice of a negative SOA (at least at -150 ms) is not appropriate in the current experiment.

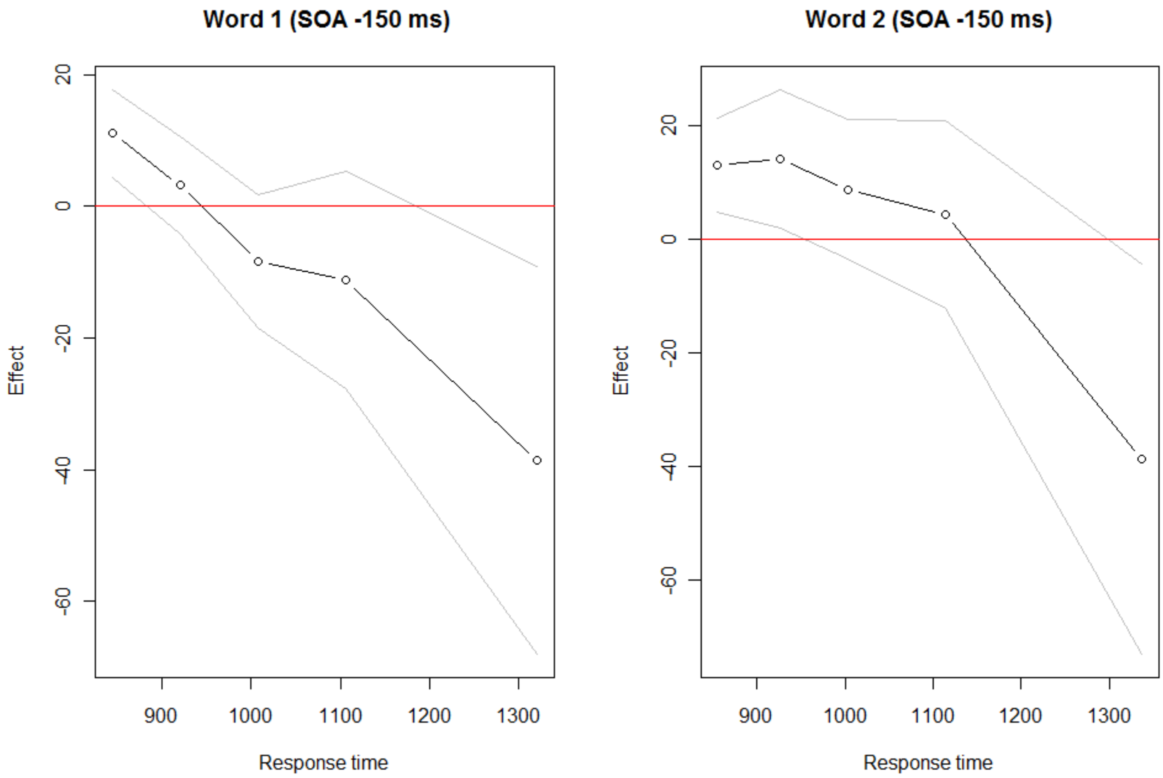

Figure 15. Delta plots for the priming effect (phonologically related or unrelated) of the first word of the NP and the second word of the NP respectively at a positive SOA (+150 ms). On the x-axis is the distribution of reaction times. On the y-axis is the size of the effect (positive values represent the facilitation effect while negative values represent an inhibitory effect). The distribution of the RTs is averaged per quantile (here 5 quantiles represented by the circles on the plot) and participants.

In sum, results from Experiment 2.a, b and c seem to demonstrate that encoding processes are not determined by order preferences in the production of French NPs and that the syntactic status of the words located in the phonological frame does not modulate ahead phonological planning. It seems that when producing NPs in French, speakers can start articulating their message as soon as the first phonological word is encoded and that the scope of encoding can be smaller than the phrase. These results are in line with the conclusion from Chapter 3.

From this conclusion can we assume that the span of phonological encoding in French NPs is limited to one phonological word? This assumption is perfectly plausible for N+A sequences: encoding of the N only in N+A NPs is in agreement not only with the literature (except for the cross-linguistic study by Costa & Caramazza, 2002) but also with Schriefers and Teruel (1999a)' smallest full syntactic phrase theory according to which the head noun determines encoding processes at least at the lexical encoding level. Encoding of the adjective only in

A+N NPs, even if it is coherent with our proposal in Chapter 3, however, is challenging on several levels. First, it is not coherent with the literature where all but one (Schriefers & Teruel, 1999a) studies report a span of encoding extending the initial word in A+N NPs. Last but not least, it can hardly account for the production of obligatory *liaison* where ahead planning is assumed to be necessary to produce that type of sequence correctly. To test whether the span of encoding varies according to inter-individual differences, we focused on A+N NPs with the inclusion of sequences involving liaison. With regards to the literature, A+N NPs are most likely to present a larger span of encoding and demonstrate, if there are, differences in encoding strategies. Experiment 3 investigates whether inter-subject variability represented by speed of initiation could modulate the span of encoding in the production of French NPs.

IV.6 EXPERIMENT 3

As underlined in the introduction, besides syntactic factors, variables linked to the subjects have also been assumed to modulate the amount of advance planning: Wagner et al., (2010) and Gillespie and Pearlmutter, (2011) reported that speakers with slower speech onset latencies presented a larger span of encoding than speakers with longer latencies. To investigate whether the lack of facilitation effect on the second word in A+N NPs in Exp. 2. can be explained by possible individual differences linked to speed of speech onset, the speakers of Exp. 3 were divided into two "speed" groups according to their mean RTs. Based on Wagner et al., (2010) and Gillespie and Pearlmutter' studies (2011), we expect to find a facilitation effect on the second word in A+N sequences for speakers with slower onset latencies only. Thus, failure to obtain an effect on N in A+N sequences in Experiment 2 may be related to speakers' initiation strategies. We tested a larger group of speakers which could be split into subgroups according to initialisation speed as was done in Gillespie & Pearlmutter´ study. In addition, to make sure that our participants behave in an experimental task as they would in natural speech context, we selected them according to their ability to produce the obligatory *liaison* correctly in the experimental paradigm. We included ¼ of obligatory liaison sequences in our material in order to exclude subjects who would display a rare production pattern in the experimental paradigms, i.e. the omission of obligatory liaison consonants. The French liaison involves both syntactic and phonological constraints which imply a larger span of encoding at least up to the phonological encoding level (see Introduction). Two conditions need indeed to be met in the correct production of a liaison in

French. On a phonological level, a final latent consonant of a word becomes realized when followed by a vowel-initial word (e.g. grand ami *great friend* would normally be pronounced (/gRB ami/) but becomes /gRB tami/ because of the liaison phenomena). On a syntactic level, liaison is obligatory only in certain types of syntactic structures, namely A+N NPs but not N+A NPs (Stark & Pomino, 2009). The omission of liaison consonants would indicate that subjects do not encode NP sequences in the experimental setting in the same way they would encode it in natural speech. Results from Experiment 3 should therefore provide us with more information on whether speech latencies affect phonological encoding processes and on whether participants employ rare encoding strategies in this kind of experimental paradigms.

Method

Participants

Sixty one French speaking undergraduate students of the University of Geneva took part in the experiment. They received course credit for their participation. All had normal or corrected-to-normal vision.

Materials

Twelve bisyllabic nouns and their corresponding pictures were selected from the French database Alario and Ferrand (1999). (See characteristics in Appendix 9). Half of the nouns started with a vowel and the other half with a consonant. Four adjectives were selected. Two of them required an obligatory liaison (*trois* (three) and *grand* (big)) while the two others did not involve any resyllabification process at all: *demi* (half) and *vieux* (old). Thus, a quarter of the sequences involved an obligatory liaison between A and N (e.g. *les trois aimants*, “the three magnets”). As in Experiment 2, each NP was associated with a distractor which was either phonologically related or unrelated to the target noun or adjective. Each noun appeared eight times in total: twice with two of the adjectives where each adjective was primed by phonologically related and unrelated distractors; twice with two of the adjectives where each noun was primed by phonologically related and unrelated distractors. Each participant produced a total of 96 NPs. The NPs were presented in pseudo-randomized order in 4 blocks which were counterbalanced across participants.

Procedure

The procedure was exactly the same as in Experiment 2.a as a neutral SOA seemed to be the most reliable SOA.

Results

Voice key failures were checked and corrected with speech analyser software. Errors, no responses, technical RT errors were discarded from the analysis and reaction times above 1300 and below 320 ms were withdrawn from the data analysis. A total of 7% of the RTs was therefore removed. Three participants were removed because of high error rate + high liaison error rate (25% or more on the total of the 96 NPs). Based on the hypothesis that the correct production of a liaison sequence requires ahead planning, we also excluded 20 participants who omitted the liaison consonant on more than 8% of the NPs involving obligatory liaison.

The 38 remaining participants were divided into two sub-groups according to their average naming latencies. A group of 19 speakers constituted the "slow group" (mean latencies: 795 ms) and the remaining 19 the "fast" group (mean latencies: 556 ms).

Spoken latencies data were fitted with linear regression mixed models (Baayen et al., 2008) with the R-software (R-project, R-development core team 2005; Bates and Sarkar, 2007). As in Experiment 2, we first separated the data into two datasets: the data where the first elements were primed (the adjectives) and the data were the second elements were primed (the nouns). The speed (fast, slow) and distractor (unrelated, phonologically related) were included in a generalized mixed model as a fixed effect variable and participants and items as random effect variables. We controlled by-participants and by-items random adjustments to intercepts. Error rates were fitted with logit mixed-effects models (Jaeger, 2008) with same random- and fixed-effects factors.

Priming of the adjective (W1)

The results are presented in Table 16.

We observe a significant effect of priming ($t(1621)= 4.751$; $p<.0001$) with longer naming latencies for the phonologically related condition (686 ms) relative to the unrelated condition (656 ms) with an effect of the speed ($t(1621)= -6.413$, $p<.0001$) but no interaction between speed and priming ($t<1$). The error rate does not differ significantly between the phonologically related condition and the unrelated condition (z<1), nor between speed groups and there is an interaction between the priming and speed groups.

Table 16

Mean RTs for Each Condition (Priming and Speed) of the Adjective

	Mean SD		***Difference (ms)***	***Error (%)***	
Speed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
Fast	570 (84)	544 (72)	-26	0.9	0.8
Slow	802 (116)	769 (104)	-33	1.2	1.8
Total	686 (100)	656 (88)	-30	2.2	1.6

Priming of the noun (W2)

The results are presented in Table 17. A main effect of priming is observed: (t(1598=-4.078, *p*<.001) and an interaction between speed groups and priming: (t(1598)= 2.739; *p*<.006). Contrasts between the two speed sub-groups show that priming is not significant for the fast speakers (t<1) while the priming effect is significant for the slow speakers: (t(759)= -3.66; *p*<.0005) with faster naming latencies for the phonological condition (790 ms) relative to the unrelated condition (820 ms). The error rate analysis indicates no significant difference between the phonologically related condition and the unrelated condition (z<1), a main effect of speed (z = -2.708, *p* = .006) with a higher error rate for the slow speakers, and no interaction between the priming condition and the speed groups.

Table 17

Mean RTs for Each Condition (Priming and Speed) of the Noun

	Mean SD		***Difference ms***	***Error (%)***	
Speed	**Phonologically related**	**Unrelated**		**Phonologically related**	**Unrelated**
Fast	556 (82)	557 (79)	2	0.9	0.6
Slow	790 (106)	820 (116)	30	1.5	1.5
Total	673 (94)	689 (98)	16	2.4	2.1

DISCUSSION

The aim of this experiment was to investigate variation of phonological planning due to inter-individual strategies and to explore whether phonological encoding of French NPs could go beyond the initial word. To this aim we only retained among our participants those who produced obligatory liaison sequences correctly to make sure that the group of participants we tested did, in theory, behave in the experimental task as they would in more natural conditions. We analysed separately participants with short and long mean production latencies. Results revealed that as long as phonological encoding of the first word of a NP is concerned, the same priming effects are observed for the two speed sub-groups of participants (fast or slow). Contrary to the results reported for the adjectives, analyses of the N in A+N revealed a priming of the noun limited to the group of slow speakers. Furthermore, even if we did not include them in the main analysis, we have to mention the 20 participants who omitted to produce liaison sequences correctly. If we consider that liaison is an indicator of ahead planning, then we suggest that those speakers who did not produce liaison sequences correctly might present a span of encoding limited to the initial word. Post hoc analysis do indeed show a lack of priming effect on the N ($t<1$) for these speakers (priming effect on A ($t(844) = 1.65$, $p < .098$). These speakers present average mean latencies (637 ms) compared to the rest of the group (556 ms for the fast group and 795 ms for the slow group). Still, they present only 81 ms difference with the fast group while they present 158 ms difference with the slow group. They show more similarities with the fast group which is in line with the fact that they present no encoding on the second word and do not produce the liaison. We will discuss this result in the general discussion.

Taken on its own, this experiment suggests that inter-subject variability can account for different encoding patterns at the level of phonological encoding in a picture naming task. This result is in line with results on advance planning at the grammatical level (Wagner et al., 2010) reporting different patterns for fast and slow subjects. In addition, the present experiment also indicates that a high proportion of speakers (30%) seems to adopt unusual speech encoding strategies while performing experimental tasks, as suggested by the rates of omission liaison consonants in obligatory contexts. This observation calls into question the reliability of the interpretation of data collected by this kind of experimental paradigm as also underlined by other authors (Jaeger et al. 2012). These results could explain why Schriefers & Teruel (1999) failed to observe a priming effect on the N in A+N in their study while most studies report a priming effect for the entire A+N NP.

IV.7 GENERAL DISCUSSION

The question of how much speakers plan ahead before they start articulating is very complex to address experimentally: lexical-phonological ahead planning in NPs has been investigated in several languages, with different experimental paradigms and very little coherence is found in the literature. The present chapter investigated whether inter-subject variability can account for the diverging results on the span of encoding of NPs in French.

Summary of the experiments

The first experiment investigated ahead planning in French NPs with a PWI paradigm and included for the first time pre-nominal adjectives in a Romance language. Experiment 1 tested the span of encoding with semantic and phonological distractors related to the noun only. A semantic priming effect was reported for the N in both A+N and N+A suggesting that the entire sequence was encoded at the lemma level at least for A+N. Experiment 2 focused on the level of phonological encoding with phonological distractors related to the noun and the adjectives at different SOAs. Results of Experiments 2.a revealed that the first element of the NP was primed by a phonologically related distractor independently of its grammatical category (noun or adjective) and independently of the order of its constituents (A+N or N+A). By contrast, no priming effect was observed when the second word was primed. Post hoc analyses revealed an interaction between phonological priming and speed of initialisation. Before investigating this result further, we verified whether failure to obtain a priming effect on W2 was not SOA related. Results from Experiment 2.b showed that a later SOA (+150) did not allow the priming effect to arise on W2. The choice of a negative SOA in Experiment 2.c proved to be inadequate for this task as an interference effect was reported for the N in N+A. The unexpected interference effect suggests that the results were probably paradigm related and not reflecting actual typical speech production encoding processes. In Experiment 3, we investigated inter-subject variability as a way to account for the divergences in results from the literature and our own results. Indeed, Experiment 3 clearly showed that slow and fast participants presented different phonological priming patterns on the last element of the NP: while the first word was primed by a phonologically related word for all speakers, only the slow speaker group presented a priming effect on the second element of the NP.

Interpretation of the results

The first point we need to underline is the fact that we observed a priming effect from semantically related distractors to the N in A+N in this chapter and a frequency effect of the adjective in both A+N and N+A in the preceding chapter. The two results converge towards a larger span of encoding at the lexical-semantic stage and are additional evidence for a lexical-semantic locus of the frequency effect in speech production.

Second, we observed a phonological priming effect on the second element of adjective-noun phrases with prenominal adjectives for slow initialising subjects. This structure has not been tested previously in a Romance language, where only post-nominal adjectives have been considered so far. Our results on A+N are in agreement with most results from studies investigating this type of structure (A+N) in Germanic languages (Schriefers & Teruel, 1999a; Dumay et al., 2009; Damian et al., submitted) where it represents the dominant structure. Whereas it is plausible that phonological encoding is limited to the initial word in N+A sequences as reported in most studies in Romance languages (Schriefers & Teruel, 1999a; Dumay et al., 2009; Damian et al. submitted), encoding of the adjective only in A+N seems less likely since the adjective does not represent a full syntactic phrase (Schriefers & Teruel, 1999a). Moreover, according to some authors (Kuipers & La Heij, 2009 and Dumay & Damian, 2011) the noun should receive automatic activation from being the "object" of the NP while the adjective being only an "attribute" will not. Then priming on the noun in A+N sequences should ease retrieval of the sequence twice as much.

An additional problem with results pointing to encoding of the adjective only in A+N is related to the production of specific sandhi phenomena such as the French *liaison* which is obligatory in such sequences. The inclusion of sequences involving obligatory liaison in Experiment 3 allowed us to identify a number of participants who omitted to produce the liaison. This suggests that participants use specific encoding strategies in experimental settings which they would not apply to natural settings. Therefore, two sources of variability linked to the participants have been identified in Experiment 3. Whereas the omission of obligatory liaison indicates that those speakers adopt specific strategies in experimental settings, it is unclear whether the source of variability among speakers with fast or slow initialisation is linked exclusively to speakers' behaviour in experimental sessions. Only speakers with long production latencies showed a priming effect on the second element of the NP while fast speakers seemed to articulate once the phonological code of the first word was available. Similar variations have already been reported by Gillespie and Pearlmutter (2011) and Wagner et al. (2010). In experimental contexts, speakers are often instructed to name the pictures as fast and as accurately as possible. Because the right balance between the two is not easy to find, some speakers might favour time and initiate speech as soon as one word is encoded while others might favour preparation of the entire message.

Results from Chapter 3 and the pattern of results of Experiment 2 and for fast speakers in Experiment 3 in the current chapter are in line with word by word incremental view of speech production. However results from slow speakers in Experiment 3 indicate that the minimal amount of encoding can extend the initial word.

Overall these results favour the hypothesis that speech is not strictly incremental but under strategic control (Ferreira & Swets, 2002; Ferreira & Engelhardt, 2006; Konopka, 2012). It is however also possible that the syntactic structure drives phonological encoding processes as a default process but that production constraints (time pressure, overcorrection, stress etc.) can overrule this default program, as claimed by Martin et al. (2010). In other words if the production context presents no specific focus, then phonological encoding processes will be determined by syntactic structure and the phrase as the default planning scope. However, if the production context requires specific encoding modalities (as for instance in an experimental paradigm), then speakers adopt different encoding strategies.

Conclusion

Chapter 3 investigated the production of single noun production and two different types of adjective-noun phrases with different experimental paradigms. We concluded that production of two-word NP extends the initial word and that different encoding processes are probably involved in the production of pre-nominal adjective-noun phrases and post-nominal adjective-noun phrases. Chapter 4 explored the amount of ahead planning in the production of two-word NPs and we reported two different results: while most of our experiments suggested a span of encoding limited to one word, two experiments suggested that encoding processes extended beyond the initial word. The purpose of Chapter 5 is to disambiguate the diverging results reported in Chapter 3 and Chapter 4. As priming paradigms present limitations in their interpretations of the time-course of two-word NP production, we will explore this question with the help of ERP analysis and compare the time-course of single- versus two-word noun-phrase production.

Chapter 5: The time-course of single- versus two-word noun-phrase production: waveform and topographic ERP analyses from stimulus to response

V.1 Introduction

In this final experimental chapter, we aim at reconciling two different observations from the previous chapters: the fact that encoding of two-word NPs seems to extend a single word as concluded in Chapter 3 with the failure to obtain a priming effect on the second element of the NP in some of the experiments reported in Chapter 4. To achieve this goal, the present study builds on the time-course of encoding underlying single word (1W) production to extend this question to the production of two word (2W) adjective-noun phrases (NP). We compared the ERP correlates of 1W and 2W NP production in a picture naming task. Since the elicitation of different types of noun-phrases requires the presentation of different pictorial stimuli, we first analysed whether different visual stimuli elicit different ERPs. In Experiment 1, participants produced only single nouns to the presentation of black-on-white line drawings and 2W NPs to coloured-line drawings or duplicated drawings. Similar production latencies were observed across the three pictorial conditions but ERPs differed for the N condition and the duplicated drawings. Experiment 2 therefore only focused on the comparison between single N and 2W NPs elicited with coloured-line drawings. Naming latencies were 53 ms longer for the production of N+A relative to N. The same sequence of stable electrophysiological activity is involved in the production of 1W versus 2W. Converging results from waveform and topographic analyses carried out on stimulus- and response-aligned ERPs indicated that the two conditions diverge in a late time-window: with first a longer stable topographic pattern for N+A between 300 and respectively 450 and 480 ms following picture presentation. This time window has been associated with phonological encoding in single word planning, thus suggesting that the cost of second word planning is reflected during phonological encoding processes of the first word. These results are discussed in light of the results from the preceding chapter but also in the light of single and multi-word production models.

V.2 The time course of single versus two-word production

The preceding chapters underlined the complexity of investigating the different cognitive processes involved in speech production especially because it involves some control on the sentence the speaker is going to produce. Different psycholinguistic research paradigms (speech error analyses, mental chronometry etc.) have led to the development of rather precise models of speech production based in particular on the production of single words. The coupling of these methods with neuroimaging techniques (EEG/MEG), allowing high temporal resolution, have allowed to sketch the time-course of encoding processes underlying single word production. The present study builds on this background to extend the question of time-course beyond single words, namely to the production of adjective-noun phrases.

V.2.1 The time course of single word production

We remember from Chapter 1 that models of speech production agree on the distinction of several encoding stages involved from intention of a message to its articulation (e.g., Levelt et al., 1999; Caramazza, 1997; Dell, 1986). Speech encoding processes start with the activation of a pre-linguistic concept. This leads to the retrieval of an abstract lexical representation (the lemma in some models). This process is also called lexical-semantic encoding. Finally, the phonological form of the word (the lexeme) is retrieved (lexical-phonological encoding) and the abstract phonological codes are transformed into articulatory plans before articulation can initiate. The time course of these different encoding processes from concept to articulation has been described by Indefrey and Levelt (2004, see also Indefrey, 2011) in a meta-analysis based on chronometric experiments and brain imaging studies on single word production in picture naming tasks. The authors estimate the following time course for the different encoding stages; visual and conceptual processes would take place from 0 to about 150-175 ms after picture presentation; lexical-semantic processes are thought to follow until about 275 ms; lexical-phonological encoding processes are then estimated to occur between 275 and 400-450 ms after picture onset. Eventually, phonetic encoding and articulation follow as the last stage (400-600 ms). This time course estimation of the production of single words is hypothetical but rather accepted among the different authors and has been supported with several recent event-related (ERP) studies (e.g., van Turennout et al., 1998, 1999; Jescheniak et al. 2002; Maess et al. 2002; Rodriguez-Fornells et al. 2002; Cornelissen et al. 2003; Jescheniak et al. 2003; Vihla et al. 2006; Koester & Schiller 2008; Laganaro et al. 2009; Strijkers et al. 2010; Zhang & Damian 2009; Laganaro & Perret 2011; Riès et al. 2011).

V.2.1 Implications with the time course of two-word production

When it comes to the production of several words, another issue arises, as the encoding time-windows are probably not just multiplied by the number of words to be encoded. A first crucial question in multi-word sentences production is how much (how many words) the speakers encode at the different processing stages before articulation of the first word. We know from experimental paradigms that initializing a single word sentence is faster than initializing multiple words sentences (results from Chapter 3 but also Jescheniak et al., 2003) which suggests that more than a single word is encoded; however, the onset latency is not a linear function of the number of words in the sentence, which means either that not all words are encoded or that some encoding processes take place in parallel. Most of the results reported in the previous chapters supported, to some extent, Levelt´s proposal, according to which the phonological word is the minimal encoding unit before articulation. Some studies from the literature also investigated this hypothesis and reported results in favour of a span of encoding limited to the first word (Meyer, 1996; Dumay, Damian, Stadthagen-Gonzalez & Perez, 2009 for the phonological encoding level; Schriefers & Teruel, 1999a for the semantic-lexical level). However, the interpretation of these studies present limitations as they did not compare the production of one word with the production of two-words NPs. This is the gap we attempt to fill based on the results from Chapter 3 and with the use of ERP analysis in Chapter 5.

V.2.2 Literature on the time-course of encoding beyond the initial word

When it comes to the time-course of encoding beyond the single word, the data is scarce. As outlined earlier, several studies have addressed questions on the time course of the different encoding processes involved in the production of one single word, usually a noun (see also Ganushchak et al., 2011 for a review on the use of electroencephalography in language production). By contrast, to our knowledge, only two studies investigated the production beyond single words with ERPs (Eulitz et al., 2000; Habets et al., 2008). Habets et al. (2008) investigated conceptual planning in a rather complex task where participants were asked to describe a scene in a chronological (“After Y did B, X did A”) and a non-chronological order (“Before' X did A, Y did B”). Their results showed significant ERP differences between the non-chronological and the chronological description of events suggesting that sentence production is sensitive to conceptual linearization. However, no implication can be driven for the dynamics of encoding of multiple word sentences relative to single nouns.

Eulitz et al., (2000) elicited the production of two-word adjective-noun phrases (a colour adjective + a noun) in a picture naming task to investigate the involvement of temporal areas in the time-period presumably associated with phonological encoding (275-400 ms). Their stimuli were colour pictures presented in four experimental conditions: a covert (silent) production of the noun, a covert production of the adjective-noun phrase, the overt production (whispering) of the adjective-noun phrase and passive viewing of the stimuli. Although the single N and the 2W noun phrases were included in their conditions, they were not contrasted as the focus of the authors was on the comparison between the passive picture viewing and the verbal response.

Thus, even though these two previous studies investigated the production beyond single words, they had very different aims and none of them has compared single and two word sentences production directly.

V.3 EXPERIMENT 1

In the following, we investigated the time-course of 2W production by comparing it to single words. To do so, we elicited the production of single nouns (1W) and of two-word (2W) adjective-noun phrases (NPs) in a picture naming task. This experiment is the same one as Experiment 1 in Chapter 3. However, relative to the behavioural studies presented above, the ERP approach will allow us to identify in which time-windows the production of 2W differs indeed from production of 1W NPs. In particular, the kind of analyses carried out on the ERP data, namely the spatio-temporal segmentation applied from stimulus to response (see below) allows us to determine which encoding processes differ or are lengthened in the production of 2W relative to 1W.

As for the other studies presented above and in the literature (e.g. Eulitz et al., 2000), we had to manipulate pictures to elicit the production of adjective-noun phrases. So, before analyzing the ERP modulations associated with language encoding processes for single versus two-words, we needed to make sure that the manipulation of the elicited visual material did not significantly modulate ERPs. The presentation of simple black and white line drawings relative to the presentation of more visually complex stimuli (e.g. coloured or duplicates) can lead to the generation of electrophysiological modulations which cannot be detected with a basic behavioural analysis. A study by Martinovic, Mordal and Wuerger (2011) indeed put forward the fact that the manipulation of picture features such as colour and luminosity in a gender decision task, but increased amplitudes in the P1 range and a latency shift in the 200-350 ms time window for coloured picture and for more complex pictures relative to simple line drawings. ERP analysis will therefore help distinguishing whether the presentation of the material used in this study (and in many other studies on speech production investigating the span of phonological encoding) generates particular processes which are linked to the manipulation of the picture rather than to the linguistic manipulation under interest. We therefore first examined the effect of picture manipulation in Experiment 1 where subjects had to produce single nouns to the same drawings that will be used in Experiment 2 to elicit two-word NPs. To make it clear, the single N only was produced independently of the pictorial condition presented on the screen in Experiment 1. This will allow us to determine whether and when (in which time-window) differences are observed between the production of the same word in response to black and white drawings and to different presentations formats of the pictures. This first experiment examined whether basic behavioural and/or ERP differences observed when producing single nouns vs. two word NPS are due to visual processes or linguistic processes. Subjects had to produce the noun corresponding to the depicted object, regardless of the arrangement of the object and of its colour. Experiment 2 will then compare the production of single nouns to adjective-noun phrases to investigate the time course of a message extending one single word.

Method

Participants

The participants were 17 native French-speakers (3 men), aged 19-33 (mean age = 25). All were right-handed as determined by subjective report and by the Edinburgh Handedness Scales (Oldfield, 1971). All participants gave their informed consent to participate in the study and were paid for their participation. The study was approved by the Geneva University ethical committee.

Material

The material was the same as in Experiment 1 in Chapter 3 (see Appendix 1 and 2). However, we will describe it again and use different names for the experimental conditions as the purpose of this experiment is different than the one presented in Chapter 3. We selected 48 monosyllabic and disyllabic French words and their corresponding pictures issued from two French databases (Alario & Ferrand, 1999; Bonin et al., 2003). The selected stimuli had high name agreement (mean 93.2%) and high lexical frequency (mean 13.85 occurrences per million words). Each corresponding picture was presented in its original black line drawing format, and in two different pictorial conditions used in behavioral studies to elicit an adjectival noun-phrase. In one condition *two* or *five* same black line drawings were presented on a same picture and spatially organized as on a dice ("dice condition" see Figure 16). In the other condition the original black lines were coloured in *green* or *red* ("colour" condition). All pictures were presented in rectangles of same dimensions (397 x 328 pixels). Half of the 48 stimuli were randomly attributed to one of each of the two non-standard drawing conditions, so that each stimulus was presented once in the standard condition, once in the "dice" condition and once in the "colour" condition. In addition to the experimental stimuli, 60 fillers were included to minimize the distance between repeated nouns. These were composed of other mono- and bi-syllabic nouns, each presented in standard black and white drawings and in one of two additional "dice" and "colour" conditions, namely "three" and "four", "yellow" and "blue". The 144 experimental and the 60 filler trials were divided into three blocks in which each noun appeared once in each condition (standard, dice, colour). The blocks and the order of the stimuli within each block were pseudo-randomized across participants to balance for order effects.

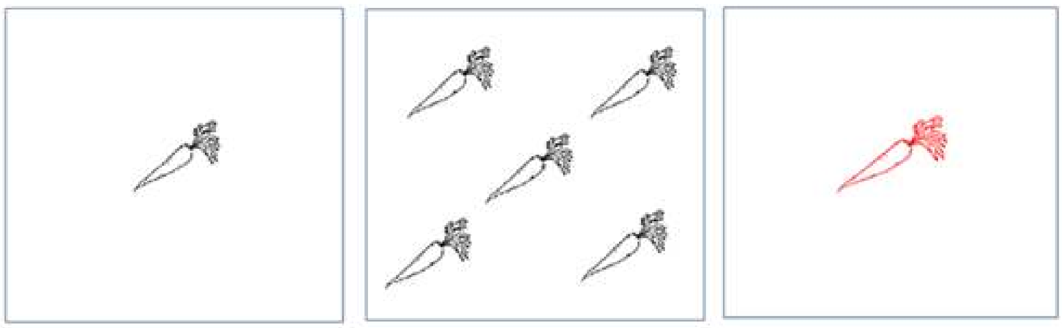

Figure 16. Example of stimuli in the *standard*, *dice* and *colour* conditions.

Procedure

The participants were tested individually in a soundproof dark room. They sat 60 cm in front of the screen. The presentation of trials was controlled by the software E-Prime (E-Studio). Pictures were presented on a grey screen to avoid extreme light exposition. The spoken responses were digitized and recorded for later response latencies and accuracy check.

Before the experiment, participants were familiarized with all the pictures and their corresponding names on a paper sheet. An experimental trial had the following structure: first, a “+” sign was presented for 500 ms. A picture appeared on screen after a 200 ms grey screen. The participant had to produce overtly the noun corresponding to the picture (e.g. “Carotte”, *Carrot*), independently of the type of presentation. The following trial started after 3000 ms. Three filler items were used for training and at the beginning of each block. The participants could take a short break after each block (after 68 items).

EEG acquisition and pre-analyses

EEG was recorded continuously using the Active-Two Biosemi EEG system (Biosemi V.O.F. Amsterdam, Netherlands) with 128 channels covering the entire scalp. Signals were sampled at 512Hz with band-pass filters set between 0.16 and 100 Hz.

Stimulus-aligned epochs of 500 ms and response-aligned epochs of 300 ms were averaged across conditions. The combination of stimulus- and response-aligned data was introduced by Laganaro and Perret (2011, see also Laganaro, Valente & Perret, 2012 for other applications): it allows the individual averaged data (and the group grand-average) to cover the actual time from picture onset to 100 ms before articulation. Response-aligned epochs covered from -400 to -100 ms before the production latency of each individual trial; stimulus-aligned epochs started at the moment the picture appeared on screen (Laganaro & Perret, 2011).

In addition to an automated selection criterion rejecting epochs with amplitudes reaching ±100 μV, each trial was visually inspected, and epochs contaminated by eye blinking, movements or other noise were rejected and excluded from averaging. ERPs were then bandpass-filtered to 0.2–30 Hz and recalculated against the average reference.

Only trials with accepted response-aligned and stimulus-aligned epochs were retained. After rejection of errors and of contaminated epochs a minimum of 30 epochs were averaged per subject for each noun-phrase condition. For the spatio-temporal segmentation analysis (see below) the stimulus-aligned and response-aligned data from each subject were merged according to each individual subject’s RT for the actual averaged trials in each pictorial condition.

Behavioural analyses

After elimination of errors, reaction times (RTs) were systematically checked with a speech analysis software, thanks to an inaudible acoustic click at the onset of the picture recorded on the second track of the recording system.

RTs were analyzed using mixed-effects models (Baayen, Davidson, & Bates, 2008) with the R-software (R-project, R-development core team 2005). The three pictorial conditions (standard, dice, coloured) were included in mixed models as a fixed effect variable; participants and items were included as random effect variables. Main effect was returned based on the ANCOVA table output by mixed model effects extended with the p-values based on denominator degrees of freedom equal to the number of observations minus the number of fixed-effects coefficients (see Baayen, 2008). Finally, planned comparisons were obtained using linear mixed model with Markov Chain Monte Carlo procedure for calculation of p-values.

ERP analyses

The ERPs were first subjected to waveform analysis to determine the time periods where amplitude differences were found between the standard and the non-standard pictorial conditions. This analysis was performed on all electrodes and data-points. Then spatio-temporal segmentation analyses were performed on the grand-averages from each condition and statistically tested in the single subjects' data as described below.

Waveform and global field power analyses

Waveform analysis was carried out in the following way: ANOVAs were computed on amplitudes of the evoked potentials at each electrode and time point (around every 2 ms) over the whole period with condition as a within subjects factor at each electrode and time point (every 2 ms) on stimulus-aligned and response-aligned ERPs. To correct for multiple comparisons, only differences over at least 5 electrodes from the same region out of 6 regions (left and right anterior, central, posterior) extending over at least 20 ms were retained with an alpha criterion of 0.01 (Guthrie & Buchwald, 1991). Then, planned comparisons (paired t-tests) were computed at each electrode and time point between the standard black line drawing condition and each other condition. For differences in *global field power* (GFP, or standard deviation of all electrodes at a given time, see Lehmann & Skrandies, 1984), paired t-tests were computed on the GFP at each time-point, with an alpha criterion of 0.05 and a time-window of 20 ms of consecutive significant difference.

Topographic pattern analysis

The second analysis was a topographic (map) pattern analysis (spatio-temporal segmentation analysis). This analysis is based on the principle that the electric field configuration at the scalp (topography) remains stable during intervals varying from tens to hundreds of milliseconds, with short transitions of instability between periods of stable topographies. The objective then is to identify the time-windows of stable topographic configurations and compare them across experimental conditions. Spatio-temporal segmentation allows to summarize ERP data into a limited number of topographic map configurations using hierarchical clustering using Atomize and Agglomerate Hierarchical Clustering and identifying time periods during which different experimental conditions evoke different configurations or distributions of the electric field at scalp.

This method is independent of the reference electrode (Michel, Thut, Morand, Khateb, Pegna and Grave de Peralta, 2001 and Michel, Murray, Lantz, Gonzalez, Spinelli and Grave de Peralta, 2004) and insensitive to pure amplitude modulations across conditions (topographies of normalized maps are compared). A modified hierarchical clustering analysis (Michel et al., 2001; Pascual-Marqui, Michel & Lehmann, 1995), the agglomerative hierarchical clustering (Murray, Brunet & Michel, 2008) was used to determine the most dominant configurations of the electric field at the scalp (topographic maps). A modified cross-validation criterion was used to determine the optimal number of maps that explained the best the group-averaged data sets across conditions. Statistical smoothing was used to eliminate temporally isolated topographic maps with low strength (Pascual-Marqui et al., 1995). Additionally, a given topography had to be present for at least 10 time frames (20 ms).

We first applied a spatio-temporal segmentation on the three grand average data (standard, “dice” and “colour”). Then, the pattern of map templates observed in the averaged data was statistically tested by comparing each of these map templates with the moment-by-moment scalp topography of individual subjects’ ERPs from each condition. Each time point was labelled according to the map with which it best correlated spatially, yielding a measure of map presence. This procedure referred to as ‘fitting’ allowed to establish how well a cluster map explained individual patterns of activity (GEV: Global Explained Variance) and its duration in ms. These analyses were performed using the Cartool software (http://brainmapping.unige.ch/Cartool.php). This procedure is described in detail in Murray et al. (2008) and Michel et al., (2009) and a step by step tutorial is provided in Brunet et al. (2011).

In order to analyse whether a specific electrophysiological pattern map is more representative of one condition or whether it lasts longer in one condition, GEV and durational measures observed in each subject's data were used for statistical analysis. As distribution of duration and GEV are not normally distributed, Friedman tests were computed on duration and GEV with NP condition as within subject factor. In case of significant effect of condition, planned comparisons (Wilcoxon tests) were applied to duration and GEV measures between conditions.

Results

Behavioural Results (RTs)

Errors, technical problems and outliers (RTs above 1100 and below 450) represented 9% of the trials and were discarded from the analysis. Mean production latencies were 710 ms (SD=84) in the standard condition, 726ms (SD=82) in the "dice" condition and 707 ms (SD=79) in the "colour" condition. The mixed effect models revealed no significant effect of the visual condition (F(2, 1735)= 1.54, p=.21).

ERP results

Figure 17 (A and B) shows the time points of significant amplitude differences across visual conditions. ANOVAs reveal significant differences on anterior left at 100-130 ms after picture onset, and more systematically on left and right posterior and anterior sites from ~180 ms to ~350 ms. On the response aligned ERPs amplitude differ across conditions on a few electrodes around 350ms before the onset of articulation. Paired comparisons showed that different amplitudes in the same time windows observed in the previous analysis only appear in the comparison between the standard and the dice condition; ERPs do not differ between the standard and the coloured condition (see Figure 17 B).

GFP diverge across standard and dice condition in the 240-290 and 400-500 ms time windows, whit no difference between standard and coloured drawings.

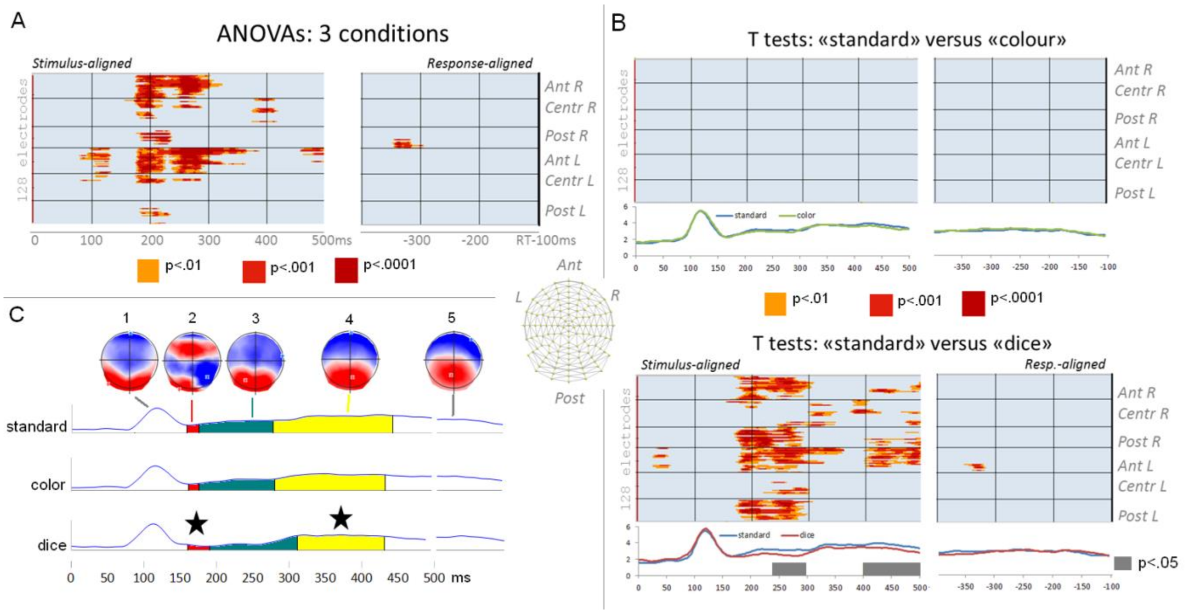

Figure 17. **A.** Significant differences between conditions (ANOVA *p values*) on ERP waveform amplitude on each electrode (Y axes) and time point (X axes) in Experiment 1. **B.** Significant differences between the standard and colour condition (top) and between the standard and dice condition (bottom) and global fit power of each condition. **C.** The temporal distribution of the topographic maps revealed by the spatio-temporal segmentation analysis is displayed under the GFP for each condition, with map templates for the five stable topographies (positive values in red and negative values in blue). Topographic maps displaying significant differences across conditions are marked with an asterisk.

The spatio-temporal segmentation analysis applied from 50 ms after picture onset to 100 ms before the onset of articulation reveals the same 5 topographic maps in the three conditions (explained variance: 97.9%), but with slightly different distribution in the dice condition relative to the other two visual conditions (see Figure 17 C). The fitting in the individuals in the time-period from 50 to 500 ms reveals no difference on first topographic map (Map “1”) neither on map duration nor GEV ($zs<1$). The second period of topographic stability (Map “2”) starts around 160 ms in all conditions, but lasts on average 15 ms longer in the dice condition. The difference across conditions is significant on duration (Friedman χ^2 (2)=5.68, p=.057; standard versus dice: Wilcoxon z = -2.63, $p<.01$; standard versus colour: Wilcoxon z<1), but not on GEV (Friedman χ^2 (2)=4.59, p=0.1). The following map template (Map “3”) is shifted 20 ms later in the “dice” condition but this shift leads to significant difference between the maps (Friedman χ^2 (2)=1.14, p=.26). The fourth period of topographic stability was on average 30 ms shorter in the dice condition (on duration: χ^2 (2)=6.44, $p<.05$; standard versus dice: Wilcoxon z=-2.2, *p*<.05; standard versus colour: Wilcoxon z=-1; and on GEV: χ^2 (2)=10.94, *p*<.004; Wilcoxon z=-2.39, p<.02 for the standard-dice comparisons; Wilcoxon z<1 for the standard-colour comparison). Finally, Map "5" does not present any difference on map duration nor GEV (zs<1).

DISCUSSION

Experiment 1 presents two main results. On the one hand, production latencies of single word production do not differ across different pictorial arrangements. On the other hand, while ERPs do not differ between standard black and white and coloured line drawings, a modulation of ERPs is observed in the dice arrangement in different time widows, namely around 100 ms, from 180 to 300 and around 400 to 500 ms. The topographic analysis revealed that the differences do not correspond to different brain generators, but to different strength of the electric field and different duration of the same stable electrophysiological patterns, with a shift in time of some periods of topographic stability.

Crucially for our purpose here, similar ERPs and RTs were observed when subjects named a picture from a black and white line drawing or from a coloured line drawing, whereas the multiplication of the line drawings leads to ERP modulations which largely extend beyond the time window associated with visual processes. The spread of ERP differences beyond visual processes between the standard and the dice condition prevents the reliable comparison when eliciting single versus two-word NPs from these two conditions. By contrast, the absence of ERP differences between our black and coloured line drawings allows us to use these two conditions to elicit different NPs. As a consequence, in Experiment 2, we compared only the production of single word elicited from the black and white line drawing to 2Ws elicited with the coloured line drawing. Other theoretical and methodological consequences of these results will be discussed in the general discussion.

V.4 EXPERIMENT 2

The present experiment is based on the exact same material and procedure as in the previous experiment, except that participants are asked to produce adjective-noun phrases to describe the modified (dice and colour) drawings. Based on the results of Experiment 1, the analyses are only carried on the single N condition and on the colour condition (noun + adjective sequences or NA).

Method

Participants

The subjects were 17 native French-speakers (3 men), aged 21-36 (mean age = 26), none of them participated in Experiment 1. All were right-handed as determined by subjective report and by the Edinburgh Handedness Scales (Oldfield, 1971). All participants gave their informed consent to participate in the study and were paid for their participation. The study was approved by the Geneva University ethical committee.

Materials

The same 48 nouns and their corresponding pictures from Experiment 1 were used in Experiment 2. In addition to the 144 experimental stimuli, the same 60 fillers from Experiment 1 were included. The colour condition elicited noun+ adjective NPs (e.g. *carotte rouge*, red carrot) whereas the dice condition elicited adjective+noun sequences (e.g. *deux carottes*, two carrots). Although the latter sequences will not be analysed due to the results of Experiment 1, keeping them ensured that the design and the results of Experiment 1 and Experiment 2 were fully comparable and that the sentences did not always start with a noun. Stimuli were presented in three blocks: each noun appeared only in one condition in a block (standard-N, colour-NA, *filler- dice-AN*). The order of the stimuli in each block and the order of the three blocks was pseudo-randomized across participants.

Procedure and analyses

The procedure and analyses followed exactly the one from Experiment 1 except that the subjects were instructed to produce a single noun for standard black and white drawings (eg. “carotte”), a noun + a colour adjective (NA) in the “colour” condition (eg. “carotte rouge”). For the *filler “dice” condition*, they had to produce a numeral + the noun (AN) in the (eg. “deux carottes”). This means that for the ERP analyses, waveform comparisons will be carried out following the same procedure as for Experiment 1 but between only two conditions. Similarly, the topographic analysis will be run on the N and NA data. This means that the spatio-temporal segmentation will be run on the grand-averages of N+NA and fitted back to the individual ERPs of these two conditions following the same procedure as described earlier.

Results

Behavioural Results (RTs)

Errors, no responses, technical errors as well as RTs above 1450 and below 450 were discarded from the analysis. A total of 7% of the trials was therefore removed. Mean RT are approximately 53 ms faster for single N production (648 ms) than for 2W NPs (NA: 701 ms): N vs. NA: $t(1324)= 4.03$ $p<.0001$).

ERP results

Figure 18 shows the time points of significant amplitude differences across single noun and two word noun-phrases conditions. Significant difference between standard-N and colour-NA appear from 180 to 230 ms and between 400 and 300 ms before articulation in the response-aligned ERPs. GFP diverge between conditions in the same time windows of diverging amplitudes, except for an additional period of difference in GFP in the colour-NA condition around 200 ms before articulation.

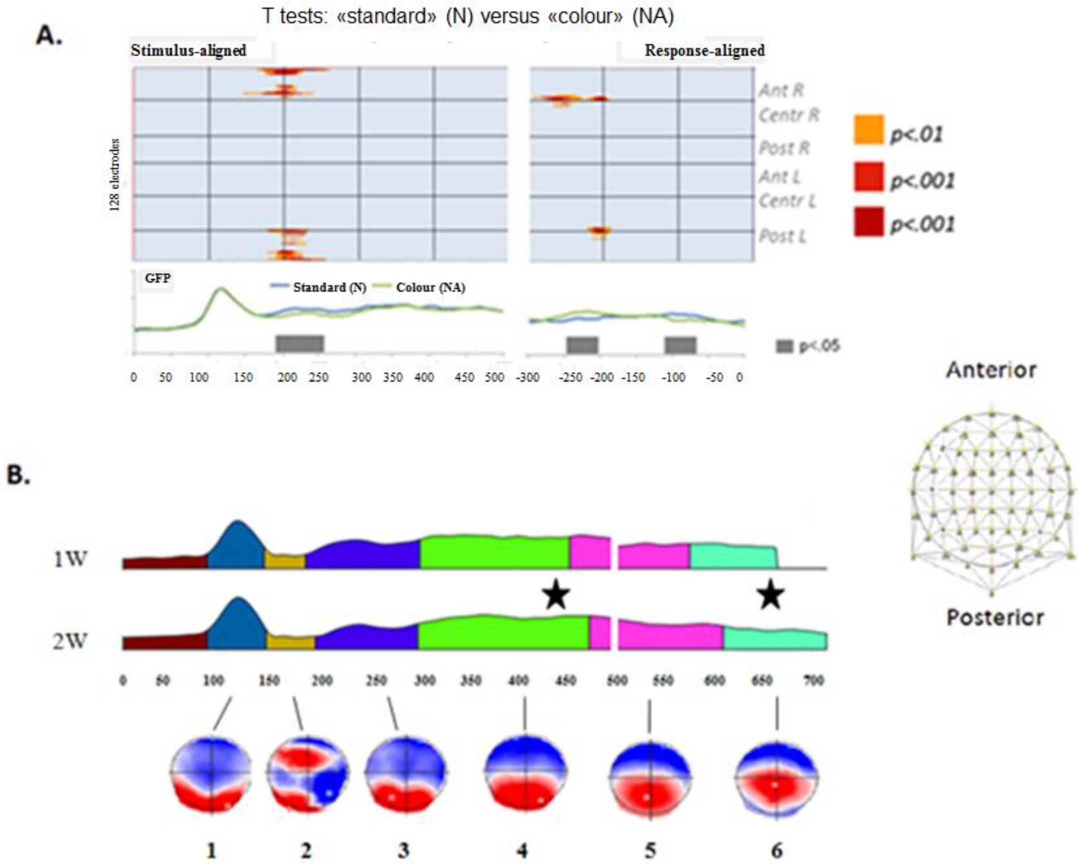

Figure 18. **A.** Top: significant differences (paired t-test *p* values) on ERP waveform amplitude on each electrode (Y axes) and time point (X axes) between the AN noun-phrase and the single noun condition and global fit power in each condition. **B.** Grand average ERPs (128 electrodes) from each condition in Experiment 2 and temporal distribution of the topographic maps revealed by the spatio-temporal segmentation analysis with map templates for the six stable topographies (positive values in red and negative values in blue). Topographic maps displaying significant differences between N and the NA noun-phrase condition are marked with an asterisk.

The spatio-temporal segmentation analysis applied to the averaged data from 50 ms to 100 ms before the onset of articulation reveals 6 different topographies accounting for 96 % of the variance. The same sequence of topographic maps is observed in the two conditions, but with different durations (see Figure 18 B).

No differences are observed on Map “1” (map duration: z<1 and GEV<1). The map template labelled “2” in Figure 15 B has its onset at ~150 ms after picture presentation in both conditions, but lasts 14 ms longer in NA relative to single N. Nevertheless, these differences are not significant neither on duration (Wilcoxon z<1) nor on GEV (z<1) for Map “2” between the two conditions.

No difference was observed between N and NA on duration and GEV (zs<1) of the following map (Map “3”). Topographic map 4 lasts 30 ms longer in the NA condition than in the N condition. The difference across conditions is observed on duration (z=-2.296, p<.0216) but not on GEV (z<1). No significant difference appears between N and NA on Map “5” (z<1). A difference appears for map “6” in the fitting in the individuals (z=-1.92, p<.055) with a longer duration for the NA condition (20 ms) relative to the N condition but no difference on GEV (z<1).

In sum, the production of 2W noun-phrases relative to 1W elicited on average 53 ms longer production latencies and ERP differences, both in waveforms and in the distribution of stable topographic configurations. On amplitudes, differences appear across conditions between 180 and 230 ms and between 400 and 300 ms before articulation. Only the latter time-period also converges with differences observed in the topographical analysis: neither in maps nor in map duration. It appears that the same sequence of functional electrophysiological patterns characterised 1W and 2W noun-phrase production, but with different durations across conditions around 400 ms. These results indicate that the 53 ms additional cost when producing 2W NPs is not distributed across all encoding processes, but is likely to be due to longer processing time at specific encoding processes, which we will discuss in the following section.

DISCUSSION

The main purpose of this study was to investigate the time-course of two-word encoding relative to single word NPs.

Experiment 1 was run to verify that ERPs were comparable when the production of the same single word NPs was elicited by stimuli with different pictorial characteristics. Three conditions were investigated: simple black and white line drawings (standard), coloured line drawings (*colour* condition) and the multiplication of a single black and white line drawing (*dice* condition). Speakers named only the single N represented in the three different conditions. No differences in naming latencies were reported across the three conditions and no ERP modulations between the standard condition and the colour condition were observed either. However, ERP modulations appeared in several time-windows extending from 100 ms to 400-500 ms in the dice condition relative to the standard condition. Spatio-temporal analyses confirmed this result with different distributions of two periods of stable topographic activity (Maps "2" and "4") between the standard and the dice conditions. Since differences in processing seemed to occur in the dice condition relative to the standard condition, the comparison in Experiment 2 was carried out only between the production of single N (one word) from the standard pictures and the production of 2W elicited with the coloured pictures.

Behavioural results indicated that production latencies are on average 53 ms longer when subjects produce a 2W noun phrase relative to a single noun. The difference in production latencies seems to be entirely accounted for by longer lasting stable electrophysiological process after 300 ms (Map "4") and 600 ms (Map "6"). This difference in duration across the two conditions for these two stable topographic patterns (respectively 30 and 20 ms) is very close to overall differences in RTs (53 ms) between single word and 2W production.

Based on these results the following consequences can be drawn on the time-course of 2W production relative to single noun.

Producing a noun versus a noun and a colour adjective

As no differences were observed across conditions in Experiment 1 (standard versus colour pictures), the longer naming latencies in adjective-noun phrase production in Experiment 2 are not due to the visual characteristics used to elicit NPs; they are therefore likely to be linked to language encoding processes.

We reported significant difference between standard-N and colour-NA appearing from 180 to 230 ms and between 400 and 300 ms before articulation in the response-aligned ERPs. GFP diverged between conditions in the same time windows of diverging amplitudes, except for an additional period of difference in GFP in the colour-NA condition around 200 ms before articulation. The differences of amplitudes observed between 180 and 230 ms are occurring in the time windows associated with semantic processing. Nevertheless, these differences are not observed on the topographical analysis: neither in maps nor in map duration. The later significant amplitude differences (between 200 and 300 ms before speech onset), however, do converge with topographical analyses.

The same sequence of topographic maps were observed across different visual properties of the stimuli (Exp1) and across conditions eliciting different number of words in the utterance (one versus two), indicating that the same brain generators are involved in single versus 2W production, but with a different time-distribution, i.e. different durations of the same stable electrophysiological activities.

In the estimated time course of single word production reviewed in the Introduction (Indefrey & Levelt, 2004; Indefrey, 2011), phonological encoding is considered to occur between 275 and 400-450 ms after picture onset and phonetic encoding to be engaged after 400 ms. Accordingly, longer production latencies in the 2W noun-phrase production relative to single word production in Experiment 2 seem to be due to more costly phonological and phonetic encoding.

The question then is why only late encoding processes, probably corresponding to phonological-phonetic encoding, are lengthened in two-word production relative to single word production. As reviewed in the introduction, different proposals have been made regarding the amount of ahead planning in noun-phrase production. Some authors argue that the entire NP (2 PWs) is planned up to phonological encoding (Costa & Caramazza, 2002; Damian & Dumay, 2009; Alario & Caramazza, 2002), whereas others claim that only the first word (1 PW) is encoded (Meyer, 1996; Schriefers & Teruel, 1999a; Schriefers, 1992, 1993).

The observation that electrophysiological activities are very similar across conditions in the first 300 ms suggests that a single word is processed during the first 300 ms in all conditions. It seems that the cost of second word encoding (the adjective in this case) only takes place after 300 ms, probably in parallel with the phonological encoding of the first word, lengthening this process. Thus, we would like to argue here that in the production of noun + adjective, the encoding process is incremental until phonological encoding and that during phonological and phonetic encoding other words can be prepared. One question here is why only specific encoding time-periods support this cost. A few studies have suggested that different encoding processes may require different degrees of attentional demand, i.e., that some processes are more automatic than others (Roelofs, 2008). For instance, Ferreira and Pashler (2002) showed that a concurrent task such as a tone-discrimination task interferes with lexical selection but not with phonological encoding during word production, thus showing that phonological encoding processes are more automatic than lexical (lemma) selection. Therefore, one may suggest that encoding processes of the second word can initiate as soon as the encoding of the initial word has reached an "easier" stage of encoding, which seems to be phonological encoding. An additional argument for encoding of the second word during phonological encoding of the initial one is can be found in the architecture of speech production models. For instance, Levelt (1983, 1989) includes an "inner monitoring loop" which allows to detect potential mistakes the speaker is about to produce and remove them from the so-called phonetic plan (input to the articulatory system) before speech initiates. The moment by which the encoding of the initial word is fully accomplished and validated by the inner monitoring loop corresponds approximately to the phonological encoding stage. As encoding of the initial word reaching this stage is reliable, it seems likely to be an appropriate period to initiate encoding process of the following word.

Finally, a major argument for extending sentence planning beyond the initial word before starting to articulate is linked to the need to ensure speech production fluency, as planning one word at a time would probably result in scattered and influent speech.

If it is the case that linguistic encoding of a second word in NP production occurs during the final encoding processing of the first word, one question is how far speakers encode the second word, i.e. is it encoded only lexically, or also phonologically? Some results of psycholinguistic studies using behavioural paradigms with the same sequences (noun + colour adjectives) propose that the second word (the colour adjective) is only partially encoded by the moment the speakers starts articulating, or at least that it is not encoded phonologically (Schriefers & Teruel, 1999a; Michel Lange & Laganaro, submitted; Dumay et al., 2009). It is therefore likely that encoding of the second word is completed during articulation of the first word which allows to keep fluent speech. However, we have no direct evidence in the present data to further discuss the amount of encoding of the second word, but this issue merits future ERP investigation.

Presentation of different types of pictorial stimuli to elicit sentence production

Another result from Experiment 1 merits further discussion, namely the observation that ERPs differed beyond the time-window associated with visual processes when participants produce the exact same words from stimuli where a same picture is duplicated relative to simpler line drawings (black and white or colour).

As mentioned in the introduction, previous studies using line drawings have reported modulation of amplitude in the P1 range associated with visual properties of the pictures for both, complexity and colour (Martinovic et al., 2011). In the present study, the coloured pictures did not diverge from the black line drawings. However, in the study by Martinovic et al, the entire picture was coloured whereas only the lines were coloured in our material. Coloured line pictures therefore seem good candidates to elicit 2W noun-phrases in comparison to single W elicited with standard pictures. By contrast, the dice condition yielded different amplitudes in time-periods which have been previously associated with lexical-semantic processes. Amplitudes and GFP were lower in the *dice* condition than in the *standard* condition whereas the short period of topographic stability between 160-190 ms lasted longer. These results suggest that visuo-conceptual processes (object recognition, see Johnson & Olhausen, 2003) take longer in the *dice* condition, but that lexical-semantic processes engage a reduced neural activity. The reason why different time distributions of electrophysiological activities were observed in the *dice* condition despite similar RTs is probably linked to the fact that some topographic maps lasted longer in the *dice* condition (longer duration for Map "2" = 15 ms and 20 ms shift for Map "3") while another period of topographic stability (Map "4") was 30 ms shorter. This result also indicates that similar behavioural responses do not necessarily correspond to similar electrophysiological activity.

Conclusion

The purpose of this chapter was to investigate the time course of adjective-noun phrases relative to the production of single words in speech production. The data presented here indicated that the same sequence of stable electrophysiological activity is involved in the production of 1W versus 2W. The longer production latencies for the production of 2W relative to 1W are associated to a longer lasting stable topographic patterns in the 300 to 450-480 after picture presentation and in the very last period preceding articulation, i.e. in the time windows usually associated with phonological and phonetic encoding. All in all, these data suggest that only the first word is encoded up to 300 ms and that encoding of the second word can be initiated during phonological encoding processes of the first word. We will integrate these results with the results from the preceding chapter in the General Conclusion.

Chapter 6: General Conclusion

VI.1 Introduction

The purpose of this thesis was to investigate encoding processes involved in the production of adjective-noun phrases in French by integrating a linguistic and psycholinguistic approach. More specifically, we investigated (1) how much ahead planning is achieved before articulation in the production of two-word adjective-noun phrases and (2) what modulates the span of encoding during speech production.

To this aim, we first compared encoding processes involved in the production of three different types of NPs (single nouns, pre-nominal adjective-noun phrases and post-nominal adjective-noun phrases) with different experimental paradigms. While the comparison of one word versus two words allowed us to investigate the span of encoding beyond the initial word, the comparison of two different types of adjective-noun phrases allowed us to examine whether encoding processes were affected by the syntactic structure of adjective-noun phrases. We will now summarize the different approaches and goals developed along the different chapters of this work and then discuss the overall results.

VI.2 Summary of the different findings

Chapter 1 presented a very brief review of the models of speech production and their different traditions (models based on the production of errors and models based on mental chronometry data). Those models allowed to sketch an architecture of the cognitive processes involved in speech production and identify the main stages realized during speaking. This work mostly focused on two of these processing stages: the semantic-lexical stage and the lexical-phonological stage. The question of how much is fully encoded at each of these processing stages during multiword production is essential to understand speakers´ ability to produce comprehensible and fluent speech. While sufficient ahead planning allows to prevent mistakes and guaranty speech fluidity, too much ahead planning might lead to cognitive overload. Levelt (1989) and other authors, who investigated the amount of ahead planning (Meyer, 1996), claimed that only one phonological word is fully encoded at the phonological level before articulation of a message. This suggest that the amount of encoding involved in the production of more than one word (here adjective-noun phrases) should be the same as the amount of encoding involved in the production of one word. In other words, production of *carotte* in French should not differ from production of *carotte rouge*. By contrast, if planning extends the initial word, production differences between the two NPs should be observed.

VI.2.1 Encoding processes in the production of 1W versus 2W NPs

This is the question we investigated in Chapter 3 by comparing production of one word (1W) versus two words (2W) in four different experiments (two picture naming tasks and their corresponding reading tasks). Length of the noun stimuli (N) was manipulated by including both short words (monosyllabic) and long words (bisyllabic) in the first experiment. All four experiments revealed a reliable difference between the production of 1W relative to 2W NPs. Additionally, we did not report a phonological length effect. Post hoc comparisons between the production of 2 monosyllabic word NP condition versus 1 bisyllabic word NP condition revealed longer naming latencies for production of two-words relative to one word of similar phonological length (two monosyllabic words + one bisyllabic word) but different content (1W vs 2W). This suggests that encoding of 2W extends the initial word. However, these results do not allow us to infer precisely how and how much of the second word is encoded during articulation of the initial word.

This question was addressed in Chapter 5 with EEG analysis where production of 1W and 2W NPs was compared. This study was principally based on the description of the time-course of single word production as sketched by Indefrey and Levelt (2004, see also Indefrey, 2011) in a meta-analysis. As for results reported in Chapter 3, behavioural results in Chapter 5 revealed longer naming latencies for the production of 2W relative to 1W. ERP analyses also presented differences between the two conditions with converging amplitudes differences and longer topographical maps occurring after 300 ms after picture presentation. We suggested that this lengthening in the time-window usually associated with phonological encoding processes corresponded to the beginning of the preparation of the following word of the message. Figure 19 in the concluding remarks, illustrates this proposal. In other words, we proposed that encoding process is incremental until phonological encoding and that during phonological and phonetic encoding other words can be prepared. This conclusion was drawn on the comparison between production of single N and production of post-nominal adjective-noun phrases as pre-nominal adjective-noun phrases were removed from the analysis due to the visual artefact they created.

VI.2.2 Encoding processes in the production of two NPs with different syntactic structure but similar phonological length

Results from Chapters 3 and 5 allowed to conclude that encoding of 2W NPs was more costly than encoding of 1W. However, as soon as one investigates encoding processes involved in the production of more than one word, different linguistic implications should be considered.

These implications were addressed in the light of the linguistic literature on adjective-noun phrases in French in Chapter 1. We underlined the fact that the syntactic structure and especially the position of the adjective within the NP in French were not arbitrary. Whether the adjective is placed before or after the noun can have implication at all the levels of encoding. At the semantic level, pre-nominal adjective-noun phrases are described as presenting a tighter semantic relationship between the noun and the adjective (Bouchard, 1998, 2002). This closer connection between a noun and a pre-nominal adjective is also observed at the phonological level with specific syntactic and phonological sandhi phenomena such as the liaison in French. Moreover, different factors reported to affect cognitive processes favour pre-position for adjectives within a NPs. These factors include lexical frequency and phonological length. Highly frequent and short phonological adjectives are more often pre-nominal. Finally, a major distinction between the two structures (A+N and N+A) is the fact that A+N sequences seem to be a default structure by (1) being the eldest structure in French and (2) by being the canonical structure from a generative view of grammar as a cognitive architecture. Taken together, these different elements seem to suggest that encoding processes involved in the production of A+N NPs relative to N+A NPs should be achieved in a more straightforward and systematic fashion. As a consequence, the cognitive cost of the production of A+N NPs should be less consequent than the cognitive cost involved in the production of N+A sequences. Such a cost should be reflected in the measure of naming latencies and this is actually what we observe all along the twelve experiments in this work comparing A+N and N+A.

VI.2.3 The syntax and phonology interface

Another closely related question we addressed by comparing two different syntactic NPs of similar phonological length is the question of whether syntax modulates phonological encoding processes. The review of the literature in Chapter 1 and 2 exposed two major accounts.

The first account, which corresponds to the so-called morpho-syntactic approach in linguistics (Selkirk, 1984, 2011; Nespor & Vogel, 1986; Delais-Roussarie, 1996, 2000; Mertens, 1993, 2008) proposes that phonological grouping is indeed determined by syntactic structure. Similar accounts are proposed in psycholinguistics and the dominant hypothesis is that the clause or phrase regulates phonological encoding processes and specifies the minimal amount of ahead planning (Smith and Wheeldon, 1999; Schriefer & Teruel, 1999a; Schnur, 2009, 2011; Oppermann et al., 2010). Schriefers & Teruel (1999a) investigated this hypothesis by testing whether the smallest full syntactic phrase assessed the span of encoding in the production of adjective-NPs in a cross-linguistic study (German and French). The authors predicted a larger span of encoding for German A+N NPs (for which A+N is the first smallest full syntactic phrase) relative to French N+A NPs (for which N should be sufficient to initiate articulation). The results of their PNT with semantically related distractors confirmed their predictions. The experiments we presented in Chapter 4 are strongly related to this study. The manipulation of A+N and N+ANPs in French allowed us to test Schriefers and Teruel´s hypothesis within the same language in a priming paradigm (lexical and phonological distractors). We obtained converging results for the lexical-semantic level with an inhibitory priming effect of the noun in A+N and N+A. However, as priming of the adjective was not tested, we were limited in the interpretation of these results. A following set of experiments tested the phonological encoding level with phonologically related distractors to the nouns and the adjectives. We failed to obtain a phonological priming effect of the second word of the NPs independently of their structure. Contrary to expectations, these results do not converge with theories claiming that syntax modulates encoding processes as we did not observe a difference between phonological priming of A+N and N+A NPs in French.

Conversely, these findings corroborate with the second account on the relationship between syntactic encoding levels and phonological encoding levels. This account is the so-called strictly prosodic approach (Hirst & Di Cristo 1984; Jun & Fougeron, 2000) which stipulates that phonological and phonetic grouping processes are blind to the grammatical properties of the message.

VI.2.4 On the minimal unit of encoding

Results from Chapter 3 and 5 strongly suggest that the minimal unit of encoding was not the initial word as production of 2W NPs revealed longer encoding processes than production of 1W. Surprisingly, most results from Chapter 4 failed to show a priming effect on the second word of the NP suggesting that only the initial word is encoded before articulation. Additional argument in favour of encoding limited to one word only comes from the shorter naming latencies for A+N relative to N+A and the effect of the frequency of the adjective. This result was interpreted as follows: if one word only is encoded before articulation and that the frequency of the adjectives is higher[27] than the frequency of the nouns, then shorter naming latencies are expected for A+N relative to N+A.

These diverging findings were actually reconciled in the light of the other results from Chapter 4. These results allowed us to demonstrate that the span of ahead planning varies across speakers as proposed in other psycholinguistic studies (Wagner et al., 2010; Gillespie & Pearlmutter, 2011). While slow speakers presented a span of encoding comprising the entire adjective-noun phrase, fast speakers only seemed to encode one word prior to articulation. Some of the limitations of these findings will be detailed in section VI.3 Nevertheless, what this study allowed us to conclude is that the minimal unit of encoding is not fixed as different speakers used different planning strategies and does not seem to be modulated by syntax, at least not directly.

VI.2.5 Summary of the significant findings

One of the most significant and reliable findings to emerge from this study is that encoding of two-word NPs extends the initial word. How much exactly of the second word is encoded before articulation of the initial word cannot not be established from the results of this study. Nevertheless, evidence from Chapter 4 suggest that this amount of encoding varies depending on some constraints which are yet to specify. The fact that the amount of encoding does not seem to be fixed is an argument for strategic incrementality (Ferreira & Swets, 2002) but against radical incrementality during sentence production.

VI.3 Limitations of the current study

Several limitations to this work have to be underlined at this stage. All along these chapters, we highlighted the difficulties for psycholinguists to elicit "spontaneous" multi-word messages from participants.

VI.3.1 Elicitation of adjective-noun phrases from pictorial stimuli

Specifically for the current study, the elicitation of adjectives was a challenge across the different experiments reported here. While most studies investigating the production of adjective-noun phrases simply use colour adjectives, we had to select different types of adjectives for two main reasons. First we needed both pre-nominal and post-nominal

[27] As adjectives are fewer in the lexicon, they are used more often than nouns and both frequencies are actually not comparable.

adjectives in French and colour adjectives in French can only be post-nominal. Second, we needed a certain number of adjectives to make sure that the repetition of too few adjectives was not the reason we observed a frequency effect of the adjectives in the experiments from Chapter 3. Nevertheless and despite carefulness, results from this chapter might have been affected by an inappropriate selection of the adjectives. The first clue was the different frequency effects of the adjectives observed in the naming and the reading task in Experiment 2. The second clue was put forward in Chapter 5 as we compared production of the exact same words from different pictorial stimuli (one type where a same picture was duplicated (A+N), one type with a simple black and white line drawings (N) and one type with a simple colour line drawing (N+A)) in an ERP analysis. Different visual processes were revealed for the condition where duplicated drawings were displayed relative to the other conditions, even though participants were required to produce single words across all conditions. Experiment 1 in Chapter 3 and 5 respectively were exactly the same studies but with a different approach (behavioural in Chapter 3 and ERP in Chapter 5). However, the results were interpreted differently in the light of the ERP results.

This comparison between a simple behavioural analysis and an ERP analysis allowed to show four major limitations of behavioural paradigms.

1. First, while behavioural paradigms allow to show differences between two conditions, they do not allow to determine whether the difference is the result of an additional process or a longer process. Results from Chapter 3 only pointed towards a difference between production of 1W and production of 2W. Results from Chapter 5 allowed to go further in the interpretation of these results by coupling behavioural analysis with ERP and especially spatio-temporal analyses. Spatio-temporal analyses presented a longer map in the time-window usually associated with phonological encoding processes in the 2W condition. This observation allowed us to infer that encoding processes involved in the production of 2W relative to 1W were the same but that this longer sequence of encoding might correspond to the onset of the encoding process of the second word of the NP.
2. Second, behavioural paradigms do not allow to disentangle whether different or longer processes observed in a specific task strictly reflect linguistic processes or reveal different cognitive processes (such as visual processes for instance).
3. Third, this comparison between the two analyses also points to the drawback of using pictorial stimuli to elicit speech as they can generate important visual artefact.

4. Finally, additional evidence that the results of a picture naming task have to be interpreted with caution is the fact that some of the effects (i.e. frequency of the adjective) reported in the picture naming task in Chapter 3 were not replicated on the same material on a reading task. This contrastive result in two different tasks using the same linguistic material in a different display underlines the limitation of the use of such tasks. It is indeed difficult to identify whether the difference reflects different encoding processes (different path used in naming versus reading) or visual artefact related to pictorial stimuli.

The discrepancy between the interpretation of the results from Chapter 3 and Chapter 5 is only shedding light on the necessity to couple behavioural analyses with more precise techniques such as EEG/ERP or eye-tracking.

VI.3.2 The choice of stimulus onset asynchrony in priming experiments

The results from the literature on the span of encoding and particularly the results from Experiment 2 in Chapter 4 in the current study emphasised some of the paradigm-related problems psycholinguists can be confronted with. Particularly, the choice of an accurate stimulus onset asynchrony is a recurrent problem when designing a priming paradigm. In agreement with the literature, Experiment 2 in Chapter 4 suggested that a neutral SOA (distractor displayed at the same time as the picture to be named) was the best choice for such a task. Nevertheless, we cannot rule out that failure to obtain a priming effect on the second word (and actually first word in some experiments) was not due to an inappropriate time-window to display the distractor word. Based on Jescheniak et al.´s graded activation account, (2003), we actually suggested that the best method was maybe to use a neutral SOA for the first word of the NP and a later SOA for the second word of the NP. Appendix 10, which represents an overview of the different *delta plots* for the phonological priming effect for the first word and the second word at each SOA, suggests indeed that a later SOA for the second word might have led to an inhibitory effect as proposed by Jescheniak et al., (2003). Furthermore, if the span of encoding varies across speakers ´naming latencies, it is also likely that different SOAs might be more efficient depending on the type of speakers tested. It is therefore very difficult to determine which SOA is the best when designing a priming paradigm.

VI.3.3 Speakers ´strategies in an experimental context

Experiment 3 in Chapter 4 also highlighted a major observation. In this experiment, participants had to produce A+N NPs which included sequences with obligatory liaison.

Three major groups of participants were identified in this experiment: fast speakers with a span of encoding which seemed to be limited to one word; slow speakers with a span of encoding which seemed to comprise the entire NP and finally those speakers who, surprisingly, failed to produce the obligatory liaison correctly. Almost a third of the total of the participants omitted to produce the obligatory liaison whereas they would produce it correctly in a natural context. To account for this pattern of results, we proposed that participants use specific strategies in an experimental context. At the beginning of most (if not all) picture naming paradigms, participants are instructed to speak as fast as possible and as accurately as possible. Some speakers might chose to focus on speed (the group of fast speakers and the group of participants who omit to produce the liaison) while others might chose to focus on the accuracy of the verbal message (the group of slow speakers).

VI.3.3 Overall implications

This section underlined several limitations to the investigation of encoding processes involved in on-line speech production. The fact that the design of experimental paradigms is fairly challenging (elicitation of speech from pictorial stimuli, choice of SOA, choice of distractors, control of visual artefacts etc.) coupled with the fact that different speakers seem to present different behaviour within a similar task suggest that these data but also results from the psycholinguistic literature in general must be interpreted with great caution. As noted in the introduction, psycholinguistics as a discipline of its own is still a recent discipline. The weaknesses highlighted in the current work are revealing of the need to replicate what other authors sometimes interpret as reliable results.

VI.4 Concluding remarks

Figure 19 illustrates the encoding processes involved in the production of the 1W NP *carotte* and the 2W NP *carotte rouge* which we propose in Chapter 5. We will discuss the general findings of this work based on this model.

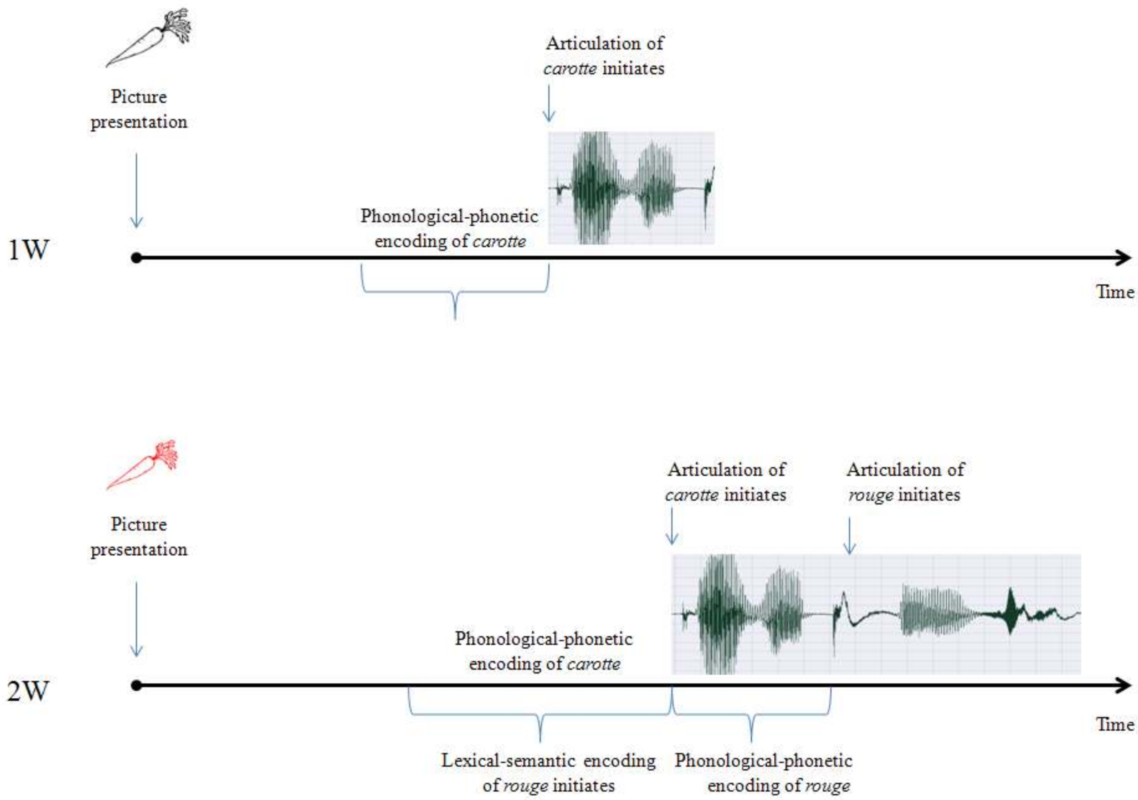

Figure 19. Illustration of a processing model accounting for the production of 1W (*carotte*) and 2W (*carotte rouge*). The time-course of W1 starts with picture presentation to articulation of the initial word. In the time course of W2, initialisation of the encoding processes of the second word (*rouge*) initiates at some point, which may vary across speakers, during phonological encoding of word 1 (*carotte*).

This illustration (Figure 19) accounts mostly for the results of Chapter 3 and 5 with regards to the encoding of 1W versus 2W. The interpretation of results from Chapter 4 (priming paradigms) is not straightforward in the light of this model. More specifically, the fact that we report a priming effect on the second word for some of the participants only. First, we recall that results from Chapter 3 and 4 suggested that the entire NP was encoded at the lexical-semantic level as a frequency effect of the adjective was reported for both A+N and N+A in Chapter 3 and because we reported a priming effect with semantically distractors for the N in N+A in Chapter 4. Deductively, variations in the span of encoding across speakers should occur at a lower level: the phonological encoding stage. In our proposal (Figure 19), encoding of the second word initiates in the time-window associated with phonological encoding (approximately around 300 ms after picture onset) of the first word. However, this time-window is fairly large and initialisation of encoding processes in that window could occur between around 300 ms until around 600 ms after speech onset for an average speaker (less for a fast speaker and more for a slow speaker). Accordingly, while some speakers might have time to process only the lexical-semantic processes of the second word while other speakers might have already processed phonological encoding processes of the second word before articulation.

VI.5 Future considerations

We mentioned in Chapter 4 Martin et al´(2010) suggestion according to which syntax might drive phonological encoding processes as a default process but that production constraints (time pressure, overcorrection, stress etc.) can overrule this program. In other words, in a neutral context, phonological encoding processes would be determined by syntactic structure and more specifically the phrase as the default planning scope. However, in a specific context such as in an experimental paradigm for instance, speakers might adopt different encoding strategies and the phrase would no longer determine phonological encoding processes.

The current study does not allow to draw conclusions on the fact that syntax is the default setting to speech encoding processes. However, the results we reported here clearly suggest that several different constraints seem to modulate the span of phonological encoding and that speech is not strictly incremental but rather under strategic control (Ferreira & Swets, 2002; Ferreira & Engelhardt, 2006; Konopka, 2012). Further work is required to establish precisely which information is used by the system to adjust the amount of ahead planning in a specific context. Speakers´ naming latencies were explored as one possible constraint modulating the amount of ahead planning. Investigating different speech constraints could allow to establish better understanding of speech planning. An attempt was made by Damian and Dumay (2007) for instance to test whether time pressure could reduce the span of phonological encoding in a picture naming task with but the authors did not observe a significant change when participants were required to respond within a certain response deadline. One can imagine to establish a relationship between the span of encoding and working memory to determine whether working memory training could benefit aphasic speakers with speech impairment. Evidence that speakers can, to a certain extent, control speech processing is indeed essential for the progress of neurolinguistic research and the development of neuro-rehabilitation treatments for aphasic patients. The assessment of what constrains the span of encoding at a specific level could help developing strategies for aphasic patients.

In conclusion, the diverging results reported in the literature on ahead planning may partly be reconciled in the light of the present results where some speakers seem to encode word by word whereas others encode beyond the first word. Crucially, this study underlines the need to focus on which variables constrain the span of encoding rather than how much is encoded before articulation, as this question may not have a unique answer.

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APPENDIX

APPENDIX 1.

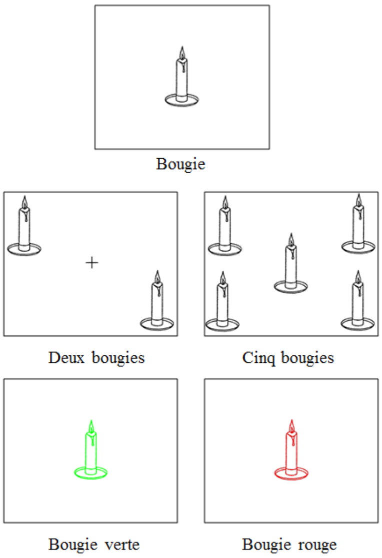
List of the 48 nouns and the four different adjectives from Experiment 1, Chapter 3.

1 syllable	Adjective		Adjective		Adjective		Adjective
Nom	Cinq	Nom	Deux	Nom	Rouge	Nom	Vert
chaine	1	bague	1	chaine	1	bague	1
chat	1	boite	1	chat	1	boite	1
chevre	1	botte	1	chevre	1	botte	1
chien	1	cage	1	chien	1	cage	1
cintre	1	corde	1	cintre	1	corde	1
cygne	1	dent	1	cygne	1	dent	1
scie	1	douche	1	scie	1	douche	1
seau	1	gant	1	seau	1	gant	1
selle	1	gomme	1	selle	1	gomme	1
singe	1	pipe	1	singe	1	pipe	1
vache	1	pomme	1	vache	1	pomme	1
vase	1	tasse	1	vase	1	tasse	1
Total	12	Total	12	Total	12	Total	12

2 syllables	Adjective		Adjective		Adjective		Adjective
Nom	Cinq	Nom	Deux	Nom	Rouge	Nom	Vert
ceinture	1	balai	1	balai	1	ceinture	1
cerise	1	ballon	1	ballon	1	cerise	1
chaussure	1	barriere	1	barriere	1	chaussure	1
chemise	1	bougie	1	bougie	1	chemise	1
cheveux	1	canard	1	canard	1	cheveux	1
cigare	1	canon	1	canon	1	cigare	1
ciseau	1	carrotte	1	carrotte	1	ciseau	1
citron	1	cochon	1	cochon	1	citron	1
souris	1	collier	1	collier	1	souris	1
velo	1	couteau	1	couteau	1	velo	1
violon	1	gateau	1	gateau	1	violon	1
volcan	1	tambour	1	tambour	1	volcan	1
Total	12	Total	12	Total	12	Total	12

APPENDIX 2.

Example of the three NP conditions from Experiment 1, Chapter 3.



APPENDIX 3.

List of the adjectives and their frequencies of Experiment 2, Chapter 3.

A+N	Frequency	N+A	Frequency
Cinq	219,29	Ancienne	48,48
Demi	153,35	Noire	168,97
Grosse	52,87	Nouvelle	197,03
Petite	331,23	Rouge	166,68
Total	189,185	Total	145,29

APPENDIX 4.

List of the stimuli including the frequency of the sequence across condition in Experiment 2, Chapter 3.

A+N	Demi	Cinq	Grosse	Petite	Total	N+A	Ancienne	Rouge	Noire	Nouvelle	Total
Low F	229	140	971	5704	1761	Low F	383	3949	949	46	1332
bague	162	143			153	bague	2490	1400			1945
bombe			2620	21100	11860	bombe			956	60	508
borne			673	576	625	borne			349	67	208
botte	917	13			465	botte	6	561			284
brosse			927	6800	3864	brosse			201	66	134
bulle	158	131			145	bulle	6	1070			538
canne			406	1060	733	canne			234	60	147
corne			131	1080	606	corne			1560	8	784
flèche	57	37			47	flèche	25	20600			10313
fraise	219	42			131	fraise	8	1670			839
poire			743	1460	1102	poire			156	5	81
poule			1300	7850	4575	poule			3190	53	1622
selle	2	57			30	selle	138	911			525
vache	89	558			324	vache	10	1430			720
High F	109	1331	4926	14374	5185	High F	181	4776	4226	367	2388
boîte			21800	68800	45300	boîte			17600	253	8927
bouche	140	159			150	bouche	10	3660			1835
branche			3430	5220	4325	branche			166	782	474
chaîne	17	2470			1244	chaîne	117	570			344
chaise	10	461			236	chaise	920	1690			1305
clef			595	2210	1403	clef			56	71	64
coupe			795	8290	4543	coupe			1130	918	1024
feuille	301	4680			2491	feuille	32	2090			1061
fleur	12	1200			606	fleur	70	15100			7585
plume			145	5730	2938	plume			5800	119	2960
prise			7520	5640	6580	prise			570	376	473
tente			196	4730	2463	tente			4260	52	2156
vis	56	226			141	vis	45	441			243
voile	228	123			176	voile	74	9880			4977
Total	169	736	2949	10039	3473	Total	282	4362	2588	206	1860

APPENDIX 5.

List of the 72 stimuli with the frequency of the sequence matched across order condition (p>1) and the ratio of the preferred position of the adjective within the NP in Experiment 3, Chapter 3.

Stimuli A+N	Frequency of the sequence	Preferred position of the adjective	Stimuli N+A	Frequency of the sequence	Preferred position of the adjective
Ancienne affaire	1230	0,597	Affaire ancienne	829	0,403
Basse pièce	16	0,045	auteurfameux	319	0,519
Brave dame	4000	0,998	Besoin nouveau	5420	0,621
Brève phase	1330	0,641	Bouche fine	647	0,464
Certain présent	184	0,518	Bruit faux	227	0,188
Chic gars	145	0,694	Couloir étroit	4040	0,474
Curieuse enquête	178	0,795	Dame brave	10	0,002
Épaisse fumée	28900	0,795	Départ mauvais	5	0,000
Étroit couloir	4490	0,526	Duo rare	202	0,201
Facile étude	8	0,022	Enquête curieuse	46	0,205
Fameux auteur	296	0,481	Étude facile	362	0,978
Faux bruit	978	0,812	Fille jeune	1640	0,001
Fine bouche	747	0,536	Fonction nouvelle	3560	0,032
Gentil passant	729	0,992	Frère proche	263	0,444
Gros père	361	0,575	Fumée épaisse	7470	0,205
Heureuse personne	102	0,014	Gant sale	3300	0,999
Immense voiture	243	0,426	Gars chic	64	0,306
Jeune fille	2130000	0,999	Histoire unique	7270	0,959
Long mois	6690	0,953	Homme seul	98200	0,201
Lourd poids	1530	0,014	Joie pure	732	0,527
Mauvais départ	14700	1,000	Légende sacrée	291	0,482
Nouveau besoin	3310	0,379	Maison petite	3210	0,011
Nouvelle fonction	107000	0,968	Meilleure pratique	6120	0,500
Petite maison	302000	0,989	Mois long	329	0,047
Pratique meilleure	226	0,500	Passant gentil	6	0,008
Proche frère	330	0,556	Père gros	267	0,425
Pure joie	656	0,473	Personne heureuse	7060	0,986
Rare duo	801	0,799	Phase brève	746	0,359
Riche roi	168	0,266	Pièce basse	338	0,955
Sacrée légende	313	0,518	Poids lourd	110000	0,986
Sainte sœur	139	0,959	Présent certain	171	0,482
Sale gant	3	0,001	Roi riche	463	0,734
Seul homme	391000	0,799	Sœur sainte	6	0,041
Unique histoire	309	0,041	Tempête violente	2790	0,007

Violente tempête	373000	0,993	Type vrai	141	0,073
Vrai type	1800	0,927	Voiture immense	328	0,574
Total	93831	0,600	**Total**	7413	0,400

APPENDIX 6.

List of the subset of 48 stimuli with the absolute ratio of the preferred position of the adjective within the NP in Experiment 3, Chapter 3.

Stimuli	Preference for pre-position	Stimuli	Preference for post-position
Affaire ancienne	0,472	Affaire ancienne	0,528
Ancienne affaire	0,472	Ancienne affaire	0,528
Basse pièce	0,534	Basse pièce	0,466
Besoin nouveau	0,645	Besoin nouveau	0,355
Bouche fine	0,492	Bouche fine	0,508
Brève phase	0,513	Brève phase	0,487
Bruit faux	0,596	Bruit faux	0,404
Certain présent	0,69	Certain présent	0,31
Couloir étroit	0,493	Couloir étroit	0,507
Départ mauvais	0,707	Départ mauvais	0,293
Duo rare	0,667	Duo rare	0,333
Étroit couloir	0,493	Étroit couloir	0,507
Faux bruit	0,596	Faux bruit	0,404
Fille jeune	0,668	Fille jeune	0,332
Fine bouche	0,492	Fine bouche	0,508
Fonction nouvelle	0,645	Fonction nouvelle	0,355
Frère proche	0,438	Frère proche	0,562
Heureuse personne	0,471	Heureuse personne	0,529
Histoire unique	0,37	Histoire unique	0,63
Jeune fille	0,668	Jeune fille	0,332
Joie pure	0,535	Joie pure	0,465
Légende sacrée	0,571	Légende sacrée	0,429
Long mois	0,491	Long mois	0,509
Lourd poids	0,437	Lourd poids	0,563
Maison petite	0,73	Maison petite	0,27
Mauvais départ	0,707	Mauvais départ	0,293
Meilleure pratique	0,67	Meilleure pratique	0,33
Mois long	0,491	Mois long	0,509
Nouveau besoin	0,645	Nouveau besoin	0,355
Nouvelle fonction	0,645	Nouvelle fonction	0,355
Personne heureuse	0,471	Personne heureuse	0,529
Petite maison	0,73	Petite maison	0,27
Phase brève	0,513	Phase brève	0,487
Pièce basse	0,534	Pièce basse	0,466
Poids lourd	0,437	Poids lourd	0,563
Pratique meilleure	0,67	Pratique meilleure	0,33
Présent certain	0,69	Présent certain	0,31
Proche frère	0,438	Proche frère	0,562

Pure joie	0,535	Pure joie	0,465
Rare duo	0,667	Rare duo	0,333
Riche roi	0,473	Riche roi	0,527
Roi riche	0,473	Roi riche	0,527
Sacrée légende	0,571	Sacrée légende	0,429
Sainte sœur	0,571	Sainte sœur	0,429
Sœur sainte	0,571	Sœur sainte	0,429
Type vrai	0,583	Type vrai	0,417
Unique histoire	0,37	Unique histoire	0,63
Vrai type	0,583	Vrai type	0,417
Total	**0,561**	**Total**	**0,439**

APPENDIX 7.

List of the subset of 34 NP stimuli with the relative ratio of the preferred position of the adjective within the NP in Experiment 3, Chapter 3.

A+N	Ratio	N+A	Ratio
Sale gant	0,000908265	Affaire ancienne	0,402622632
Lourd poids	0,013718282	Bouche fine	0,464131994
Heureuse personne	0,014241832	Couloir étroit	0,473622509
Facile étude	0,021621622	Présent certain	0,481690141
Unique histoire	0,04077055	Légende sacrée	0,481788079
Basse pièce	0,04519774	Meilleure pratique	0,5
Riche roi	0,266244057	Auteur fameux	0,518699187
Nouveau besoin	0,379152348	Joie pure	0,527377522
Immense voiture	0,425569177	Voiture immense	0,574430823
Pure joie	0,472622478	Besoin nouveau	0,620847652
Fameux auteur	0,481300813	Roi riche	0,733755943
Pratique meilleure	0,5	Pièce basse	0,95480226
Sacrée légende	0,518211921	Histoire unique	0,95922945
Certain présent	0,518309859	Étude facile	0,978378378
Étroit couloir	0,526377491	Personne heureuse	0,985758168
Fine bouche	0,535868006	Poids lourd	0,986281718
Ancienne affaire	0,597377368	Gant sale	0,999091735
Total	**0,315146577**	**Total**	**0,684853423**

APPENDIX 8.

Characteristics of the stimuli and noun distractors in Experiment 1, 2.a, b and c, Chapter 4.

Internet NP frequency					Distractors	
	Noun + *Vert* (green)	Noun + *Rouge* (red)	*Grand* (Big) +Noun	*Vieux* (old) +Noun	Phonological distractors	Unrelated distractors
Balai (broom)		868000		609000	Ballon (balloon)	Commode (drawer)
Cadenas (locker)		597000	2030000		Cadeau (gift)	Souris (mouse)
Canard (Duck)		7269000	1770000		Cafard (cockroach)	Etoile (star)
Chapeau (hat)	1680000			2120000	Château (castle)	Fougère (fern)
Citron (lemon)		1230000	1900000		Siphon (siphon)	Fourchette (fork)
Cochon (pig)	559000		3780000		Coton (cotton)	Pastèque (watermelon)
Croissant (croissant)	1420000			1150000	Croyant (believer)	Horloge (clock)
Gâteau (cake)		957000	2390000		Garrot (tourniquet)	Maison (house)
Maïs (corn)		29500000	172000000		Masseur (masseur)	Bouteille (bottle)
Palmier (palm tree)	428000		775000		Palier (langing)	Tortue (turtle)
Pinceau (brush)		840000		328000	Pincer (pinch)	Tomate (tomato)
Poisson (fish)	901000		307000		Poison (poison)	Cravate (tie)
Raisin (grapes)		1170000	2770000		Réseau (network)	Valise (suitcase)
Renard (fox)		880000		663000	Retard (delay)	Echelle (ladder)
Serpent (snake)	717000		1140000		Serment (oath)	Chemise (shirt)
Soleil (sun)	780000			5580000	Sommeil (sleep)	Poupée (doll)

Stylo (pen)	600000			435000	Styliste (stylist)	Trompette (trumpet)
Tonneau (barrel)		515000		294000	Tonnerre (thunder)	Fenêtre (window)
Tracteur (tractor)	606000			254000	Trappeur (trapper)	Enveloppe (envelope)
Vélo (bike)		1980000		1730000	Véto (veto)	Fourmi (ant)

APPENDIX 9.

Noun stimuli and their distractors in Experiment 3,Chapter 4.

Target stimuli	Phonological distractors	Unrelated distractors
Agneau	Habit	Butin
(lamb)	(clothes)	(booty)
Aimant	Été	Moulin
(magnet)	(summer)	(mill)
Avion	Appui	Mari
(plane)	(support)	(husband)
Cactus	Castor	Dormeur
(cactus)	(beaver)	(sleeper)
Camion	Casier	Media
(lorry)	(locker)	(media)
Citron	Sigma	Respect
(lemon)	(sigma)	(respect)
Eclair	Effluve	Facteur
(lightning)	(effluvium)	(postman)
Gâteau	Galet	Debut
(cake)	(pebble)	(start)
Igloo	Iguane	Bougeoir
(igloo)	(iguana)	(candlestick)
Indien	Impôt	Fagot
(Indian)	(taxes)	(bundle)
Panier	Patio	Convoi
(basket)	(patio)	(convoy)
Pingouin	Pinceau	Muguet
(pinguin)	(brush)	(lily)

APPENDIX 10.

Delta plots for the phonological priming effect for each word (word 1 and word 2) at the three different SOAs in Experiment 2,Chapter 4.