Input factors in the processing of native and L2 processing of inflectional morphology:

Evidence from ERPs and behavioral studies

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Numerous studies have examined the processing of inflectional morphology by second language learners, with the underlying aim of determining whether native-like processing can ever be attained. Indeed, this is an area where L2 speakers show notorious deficits, in contrast to the achievement of “target-like” grammar in other areas. The present paper reviews a series of experiments performed using online measures, notably ERPs and the recording of eye-movements, to address this question. The novelty of the present work lies in its emphasis on the properties of the L2 itself, i.e. “input factors” and how they may affect learning rate.

What are the factors that affect adult learners’ capacity to acquire a new language? A large body of research has examined this topic, concentrating predominantly on factors related to the learners themselves: the difference between early and late acquisition, influence of the native language, type of input, motivation, among others (for a recent review, see Hopp, 2010). Far fewer are the studies which have examined the properties of the to-be-acquired language itself, and how they may influence learning. The present study is an attempt to further knowledge as concerns the importance of L2 properties or “input” factors.

To set the scene for the present series of studies, one need only consider the infamous orthographic challenge dubbed “La dictée de Pivot.” The objective of the nationally televised competition was to display one’s mastery of written French grammar and orthography, despite the nefarious traps and pitfalls engendered by the combination of
silent morphology and homophonous forms. Indeed, producing any length of text in French without committing a single error can be considered to be somewhat of a national sport. As underlined recently by Fayol and Jaffre (2009), written French poses difficulties at all levels, be it phonological, lexical or grammatical, and the French language can undoubtedly claim the dubious title of being one of the world’s most difficult languages to write correctly. The reasons for this difficulty lie, interestingly, outside the realm of mere complexity. In fact, over and above the intricacies of a relatively complex system of orthographic-phonological correspondence (the 36 phonemes of French can be transcribed by 130 different graphemes; Catach, Golfand & Pasques, 1976), problems arise even for extremely regular morphological inflections. As could be attested by any French school teacher or university instructor and as demonstrated in several experimental studies (Largy & Fayol, 2001; Negro & Chanquoy, 2000), both French children and, under conditions of duress or taxed memory load, French adults often fail to produce even basic morphological variations, for both verbal and nominal number as well as gender concord. The same has been found for written Dutch (Frisson & Sandra, 2002; Sandra, Frisson, & Daems, 1999).

What might underlie the difficulty to produce even regular inflections in written French? The culprit that will be examined throughout the present chapter is the absence of an overt oral cue to these morphological variations. Indeed, the vast majority of grammatical errors produced in written French (and Dutch) concern “silent” morphemes. Due to the evolution of spoken French over the centuries, its orthographic representation includes more segments than the oral equivalent, such as final consonants whose pronunciation was lost in the 14th Century. As such, the regular plural inflection “–s”, which marks the plural across all elements in the determiner phrase (DP) is marked orthographically but not phonetically for the noun and adjective (the DPs la grande maison blanche and les grandes maisons blanches
“the big(s) white(s) house(s)” differ phonetically only in the realisation of the determiner). According to Dubois (1965), a full 99% of French nouns are not phonetically distinct in their singular and plural oral forms. The same phonetic opacity is true within the inflectional phrase (IP) for regular inflections of the present tense, whereby the inflection for third person plural (-ent) differs orthographically but not phonetically from the three singular persons, which themselves differ orthographically but not phonetically between the first and third (-e) versus second (-es) person. Hence, the two verbal phrases “il donne” and “ils donnent” (he/they gives/give) are phonetically identical, as are the inflected verbal forms “je pense” “tu penses” and “ils pensent” (I/you(sing) they think/s). The same absence of phonetic realisation of morphological variation holds true for gender, both in the IP for past participle forms and in the DP for invariable adjectives.¹

**Phonological recoding during silent reading**

The effect of these homophonous morphological forms on written production is notorious, as outlined above, and is by no means limited to the French language. In addition, however, the presence of homophonous forms can also impact upon comprehension. Research over the last decade has seen a tremendous rise in the number of empirical studies, across a wide variety of languages, which support the hypothesis that phonological codes are automatically and irrepressibly activated during silent reading and indeed can have an important influence on processing (for a recent review, see Harm & Seidenberg, 2004). The effect of phonological coding on processing the written word has been shown both in studies where isolated words were presented and, more interestingly for the present purposes, in studies of words presented in sentence context. In several studies using eye movements as the

¹ The phonetic opacity of verbal forms also holds true across tense, with homophonous forms for the infinitive, imperfect and past participle forms for regular first group (“er”) verbs. For a discussion of the influence of these homophonous forms on processing in native speakers see Brissaud & Sandon(1999), Chevrot, Brissaud & Lefrançois (2003).
means of measuring processing benefits and/or costs, it has been shown that a “preview” of the phonological information contained in the upcoming word in the sentence facilitates the reading process. This has been found in alphabetic languages, such as English (Ashby, Treiman, Kessler & Rayner, 2006; Pollatsek, Lesch, Morris & Rayner, 1992; Rayner, Pollatsek & Binder, 1998; Rayner, Sereno, Lesch & Pollatsek, 1995; but see Daneman & Reingold, 2000) and French (Miellet & Sparrow, 2004), but also in non-alphabetic languages such as Chinese (Liu, Inhoff, Ye, & Wu, 2002; Pollatsek, Tan, & Rayner, 2000; Tsai, Lee, Tzeng, Hung, & Yen, 2004). The demonstration of a benefit of phonological information during reading even in non-alphabetic languages strengthens the hypothesis, as suggested by a myriad of studies, that phonological information is part and parcel of the reading process, whichever the language and/or writing system.

The above empirical evidence not withstanding, the question of how and when phonological codes become active is still hotly debated. For the present purposes, we will not enter into the dispute of whether phonological information is retrieved pre-lexically or only once a stored lexical form has been activated on the basis of orthography, thus giving rise to stored phonological information (cf. Van Orden & Kloos, 2005 for a review). We will take as a given that phonological information can indeed be activated (or retrieved) extremely rapidly. For isolated words, phonological information comes into play within the first 30 to 50 msec of visual processing, as has been demonstrated in numerous languages. In more natural settings of reading, phonological information about the word in periphery plays a role in processing, i.e. even before a word has been directly fixated. Some have argued, on the basis of this rapid availability of phonological information, that phonology in fact overrides access to meaning based on the printed word (cf. Van Orden & Kloos, 2005, for a review). This idea is far from being universally accepted (see, for example, Brysbaert, Grondelaers & Ratinckx, 2000). Again, however, such is not germane to the present discussion. We will concentrate,
rather, on the question of how phonological and orthographic codes interact during morphosyntactic processing, and how the availability of overt phonetic cues can enhance processing both in the native language and when learning a second.

**Behavioral evidence of the link between phonological cues and morphological processing**

As concerns French in particular, both monolingual studies of children and adults, as well as studies of L2 learners have revealed the importance of phonological cues to the learning and processing of morphological agreement (Arteaga et al., 2003; Colé & Segui, 1994; Frenck-Mestre, Foucart, Carrasco & Herschenson, 2009; Frenck-Mestre, Osterhout, McLaughlin & Foucart, 2008; Herschenson, 1993; Jakubowicsz & Faussart, 1998; Largy, Fayol & Lemaire, 1994; Negro & Chanquoy, 2000). When phonetic differences are available to the reader to distinguish between morphological forms, processing is enhanced. To illustrate such, consider the effect of the overt realisation of gender concord, outlined below.

In a series of experiments aimed at examining grammatical gender processing within the DP in French, Colé and Segui (1994) visually presented prime-target pairs which either agreed in gender or violated gender concord (e.g. mon<sub>masc</sub> chat<sub>masc</sub>/<sup>*</sup>ma<sub>fem</sub> chat<sub>masc</sub>, “my cat”). Gender concord errors inhibited processing, such that native French participants took longer to identify target words when the target was preceded by a gender-mismatch prime than by a gender-congruent prime. However, the effect was further modified by the presence of overt phonetic cues to gender. Primes that were both orthographically and phonetically different as a function of gender (ma/mon, la/le, cette/ce) inhibited processing of the target word when the gender of the determiner and noun were not congruent. Primes that differed only orthographically for the masculine and feminine forms (joli/jolie) did not reliably influence
The identification of the target as a function of gender concord. Hence, in the absence of an overt cue when phonologically recoded, no effect of gender concord was observed for visually presented French DPs despite the presence of a clear morphological variation.

The same type of facilitation of the overt realisation of gender concord on processing can be seen in the results from an auditory priming study (Jakubowicz & Faussart, 1998). The authors manipulated the presence versus absence of overt gender marking on a pre-nominal adjective (e.g., pauvre vs. gentil/gentille “poor” vs. “nice”), preceded by an overtly marked determiner (mon/ma “my”). The interpretation of the results of this study is in fact somewhat controversial. The authors themselves concluded from the absence of a statistically reliable interaction, despite a strong trend, that the added presence of overt gender marking on the adjective did not enhance processing. Based on this, they argued that overt marking on the adjective was not productive, given that the determiner suffices to set feature checking processes into motion. Nonetheless, the interference produced by gender-mismatched adjectives, in addition to the determiner, was twofold in the case of overtly marked adjectives. As such, the data from this experiment, with spoken materials, are in line with those reported for written stimuli showing that the overt phonetic realisation of gender cues provide a more reliable cue to agreement.

**ERP signatures of morpho-syntactic agreement processing**

While the above cited studies of native-language processing clearly show an effect of the overt realization of phonology on morphological processing, the majority have employed tasks that require an overt response from the participant. Another fruitful approach, which we

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2 It can be noted that the two types of prime also differed as concerns word class, being closed class in the case of determiners (ce/lette, etc.) and open class for adjectives (joli/jolie, etc.). Indeed, the authors aim was to examine word class, not phonetic realization, even though the two factors were confounded.

3 This line of argumentation fits nicely with work suggesting that the determiner plays a crucial role in setting agreement features for the entire noun phrase. For example, representational accounts subscribing to Minimalism describe the nominal domain as the Determiner Phrase, in which the core noun (which carries the interpretable features of number and gender) shares its features with the other projections of the DP (such as adjectives, quantifiers, determiners), and is in turn affected by the determiner’s syntactic properties in a given language.
will examine in greater detail, is the use of event-related potentials (ERPs) to study linguistic processing. ERPs provide an online record of the electrical activity of the brain elicited by external stimuli, such as auditory or visually presented words in sentence contexts. They have become a standard tool to study both native and second language processing because of the temporal resolution they provide, which is highly desirable for studies of language processing (for recent reviews see Foucart & Frenck-Mestre, in press b; McLaughlin, Tanner, Pitkänen, Osterhout, Frenck-Mestre, Inoue & Valentine, in press), and because they can be used to delineate stages of grammatical acquisition in adult L2 learners (Osterhout, McLaughlin, Kim & Inoue, 2004; Osterhout, McLaughlin, Pitaken, Frenck-Mestre & Molinaro, 2006; McLaughlin et al., in press; Rossi, Gugler, Friederici, & Hahne, 2006).

Of particular interest for the present purposes are three well known ERP signatures, namely the P600, the N400 and the “LAN” which today is in fact better classified as belonging to a broad class of early negativities. To date, all monolingual studies that have investigated the online processing of gender concord using ERPs have revealed a P600 effect in response to agreement violations in sentence context. This effect has been reported in various languages, including Dutch (Hagoort, & Brown, 1999), French (Foucart, & Frenck-Mestre, in press a; Frenck-Mestre, 2005; Frenck-Mestre et al., 2009), German (Gunter et al., 2000), Hebrew (Deutsch, & Bentin, 2001) and Spanish (Barber, & Carreiras, 2005, Gillon Dowens et al., 2010). The P600 effect is obtained regardless of the elements involved (e.g., article-noun, adjective-noun, reflexive-antecedent) or the position of violations (within the DP or across a syntactic boundary). It is sometimes preceded by a LAN effect (Barber, & Carreiras, 2005; Deutsch, & Bentin, 2001; Gunter et al., 2000), but not consistently (Foucart, & Frenck-Mestre, in press a; Frenck-Mestre, 2005; Frenck-Mestre et al., 2009; Hagoort, & Brown, 1999; for a recent discussion of the LAN, see McLaughlin et al., in press). The common theory that emerges from these studies is that in L1, grammatical gender is
represented syntactically, and that the online processing of gender concord is not a conceptual and/or semantic, but a syntactically driven process. In L2 processing, the presence of a P600 effect in response to gender concord violations has also been reported, but less systematically (cf. Foucart & Frenck-Mestre, in press b).

In addition to the presence of anterior negativities and the P600 in response to morphosyntactic agreement violations, a series of longitudinal and cross-sectional studies of adult L2 learners has found that in early stages of acquisition a different pattern obtains (see McLaughlin et al., in press, for a review). In lieu of the typical P600 response, an N400 response has been reported to be elicited by grammatical violations in L2 learners. This has been found for violations of subject-verb agreement in two independent studies for English native speakers acquiring French (Osterhout et al., 2004; McLaughlin et al., in press), as well as for English native speakers acquiring German (Tanner, Osterhout & Herschensohn, 2009). In these studies, and as discussed in greater detail in the next section, the N400 response was found to be supplanted, in more advanced stages of acquisition, by the more typical P600, leading the authors to suggest that the two electrophysiological markers may be used to index stages of grammatical competence. Interestingly, an N400 response has also been found in L2 French learners when processing gender agreement violations within the DP. This has been reported for English native speakers at an intermediated level of learning when processing pre-nominal adjectives in French (Foucart & Frenck-Mestre, 2007, in prep) and, in very early stages of acquisition for L1 English speakers when processing post-posed adjectives (Carrasco & Frenck-Mestre, 2010, in prep). The exact nature of the N400 effect to syntactic manipulations remains an open question at present although, as stated above, it may indeed be a hallmark of early acquisition.

The beauty of ERPs lies in their capacity to reveal linguistic processing and eventual difficulties in processing, independent of any overt response on the part of the participant.
They are also tightly linked to immediate processing, as opposed to later stages of processing when strategic processes have time to come into play. Several psycholinguistic studies, outlined below, have indeed capitalized on this to examine the main question of interest for the present purposes, namely how phonological cues can influence the processing of inflectional morphology, in both native speakers and L2 learners.

**ERP evidence of the link between phonological cues and morphological processing: the case of gender concord**

Given the evidence of ERP sensitivity to morpho-syntactic processing, both in native speakers and in L2 learners, and given the behavioural evidence that overt phonological cues aid in the learning and processing of morpho-syntactic agreement, we are in the interesting position of being able to examine the reader’s online sensitivity to these cues, using ERPs. Moreover, we should be able to evidence differences in learning rate for L2 acquisition and native speakers’ sensitivity to agreement as a function of oral cues. Indeed, a reasonable prediction might be that the presence of phonological cues can lead to faster learning of relevant morphemes in the L2 and more consistent processing of these morphemes in native speakers.

In an ongoing series of studies, we are currently investigating online morpho-syntactic processing for native French controls and adult L2 learners of French, using ERPs as the tool of investigation (Carrasco & Frenck-Mestre, 2007; 2009; 2010, in prep; Frenck-Mestre et al., 2008, 2009; Foucart & Frenck-Mestre, 2007; in press a, in prep). Both gender concord within the DP and subject-verb agreement have been examined. Outlined below are a series of results emanating from these studies, which clearly show that morphological agreement, in written French, is processed more efficiently when agreement is overtly realized phonetically. Interestingly, however, the patterns of results were not identical for native French speakers
and the various L2 learner groups. Native French speakers showed, first, a more reliable effect of phonology in that the effect was obtained systematically, across all experiments independent of the grammatical manipulation. Native French speakers also showed a larger response as a function of the systematicity of the covariation between morphology and phonology; the more regular pattern the larger the ERP response to a violation of this pattern. Neither of these results hold true for L2 learners.

In a first series of experiments (Carrasco & Frenck-Mestre, 2007, 2009, in prep.), we examined the role of overt phonetic cues to noun-adjective gender agreement in written French, for both native speakers and L2 (Spanish L1) learners. Phonetic cues to agreement were manipulated by the type of adjective, which was either variable (presence of final consonant in feminine form: [VERT/VER]) ‘green-f/m’ or invariable (no distinction in coda for invariable adjectives: [BL2] ‘blue-f/m’) with, however, distinct orthographic forms for the two forms in all cases (“vert_masc/verte_fem” “bleu_masc/bleue_fem”). The similarity of grammatical features across languages was not addressed. Indeed, in French and Spanish the rules of agreement are similar within the determiner phrase where all elements must agree in gender (and number). In addition, both the word order of nouns and adjectives and their agreement rules are highly similar in French and Spanish, for both of which the canonical order of adjectives is post-nominal and for which gender is marked on the adjective independent of its position, number or syntactic role (i.e. for attributive and predicative adjectives). Moreover, in a first experiment, lexical gender was held constant across French and Spanish (eg. chaise_f and silla_f “chair”). Examples of the type of sentences created are given Table 1, below.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable adjective</td>
<td></td>
</tr>
<tr>
<td>Feminine</td>
<td>Jean aime la F, S musique F, S *française F, S / *français M, S et le vin rouge.</td>
</tr>
</tbody>
</table>
Invariable adjective

Feminine  Jean aime la musique espagnole et le vin rouge.
Masculine Jérôme regarde un bateau bleu sur l’eau.

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**Table 1. Examples of experimental materials created to examine the effect of the oral realization of gender alternation on processing gender concord in written French.**

Results from the first experiment revealed several significant findings. First, gender concord violations within the DP elicited a large P600 effect, both for Spanish L1 – French L2 learners and for native French speakers. The effect was significant in both groups, albeit visibly larger in the group of native controls. No early negativities were elicited by gender concord violations, for either native controls or L2 learners. Second, and most importantly, there was a clear effect of the presence of oral cues to gender on gender concord. Gender concord violations within the DP produced a larger P600 effect as a function of whether the gender of the agreeing element (adjective) had an overt phonetic cue in addition to orthography (variable adjectives) or only differed orthographically (invariable adjectives). Again, this was true of both the native speakers and L2 learners. As such, our predictions are confirmed; overt phonetic cues to agreement produce a reliably stronger effect on processing than do silent cues, marked only orthographically. This result was found, moreover, even though participants passively read sentences.

In a second experiment, we re-examined the question of the use of oral cues to gender agreement, again by manipulating the type of adjective—variable vs. invariable—but with the added the factor of lexical gender overlap between languages. As in the first experiment, short sentence contexts were used, in which gender concord was manipulated between the noun and post-posed adjective. Unlike the first experiment, however, nouns either had overlapping gender in French and Spanish (eg. verre and vaso “glass”) or opposite gender across languages (eg. balai and escoba “broom”). Examples are provided in Table 2, below.
Recently, Sabourin and colleagues concluded that the presence of grammatical gender does not suffice for L2 learners to engage in automatic processing of gender agreement in their second language, but that overlapping lexical gender is in fact necessary. Sabourin and Haverkort (2003) examined German learners of Dutch while Sabourin and Stowe (2008) compared Romance and German learners of Dutch; both studies used an ERP paradigm with visually presented sentences to examine gender concord. It can be noted that the results obtained by Foucart and Frenck-Mestre (in press a) in an ERP paradigm of nominal gender concord with German L1 – French L2 learners belie this claim. Nonetheless, we wished to elucidate whether the results reported for our L2 learners in the first experiment were dependent upon the existing overlap of lexical gender across their L1 and L2. In addition, the manipulation of overt phonetic cues to gender on the adjective allowed us to examine the interaction between this factor and lexical gender. Otherwise stated, we wished to determine whether the possible inhibition of gender processing caused by differences in lexical gender across languages could be overridden by overt cues to gender concord.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable adjective</td>
<td></td>
</tr>
<tr>
<td>Same gender</td>
<td>Cette F,S boîte F,S verte F,S */vert M,S est à Julie.</td>
</tr>
<tr>
<td>Opposite gender</td>
<td>Ce M,S balai M,S léger M,S */légère F,S est très maniable.</td>
</tr>
<tr>
<td>Invariable adjective</td>
<td></td>
</tr>
<tr>
<td>Same gender</td>
<td>Cette F,S boîte F,S bleue F,S */bleu M,S est à Julie.</td>
</tr>
<tr>
<td>Opposite gender</td>
<td>Ce M,S balai M,S espagnol M,S */espagnole F,S est très maniable</td>
</tr>
</tbody>
</table>

Table 2. Examples of experimental materials created to examine the possible interaction between the oral realization of gender marking and the overlap vs. conflict of lexical gender across French and Spanish, when processing gender concord in written French. Note that both masculine and feminine nouns were used for both “same” and “opposite” gender.

Our results, which are still preliminary at the time of writing, are in fact surprising. French native controls showed the expected P600 effect to gender concord violations.
Importantly, these participants also showed an interaction between gender concord and type of adjective. As in our first experiment, native speakers showed a larger P600 effect for orally realized gender concord violations (i.e. for variable adjectives) than for silent violations (i.e. invariable adjectives), which were only marked in the orthography. We thus replicated the effect of phonological recoding on the processing of written French, showing that native speakers have a more solid representation of grammatical morphemes/orthographic variations when they are supported by phonological differences. For the L2 learners, however, a different picture arises. In this group, rather disconcertingly, no clear pattern of interrupted processing was apparent in the ERP trace to sentences containing gender concord violations. Instead of replicating our findings for the L2 group, we apparently disrupted normal processing by the inclusion of nouns which had opposite gender across their native (Spanish) and second (French) language. Moreover, the presence of overt phonetic cues to gender apparently did not help to override the general disruption caused by differences in lexical gender. At present, we are further investigating this effect to see whether individual differences may in fact be masking results. Nonetheless, and quite unexpectedly, the results for the L2 learners seemingly show that the presence of opposing lexical gender across a bilingual’s two languages suffices to disrupt the automatic process of gender agreement. Note that this claim is in fact different from that forwarded by Sabourin and colleagues; we are not suggesting that L2 learners who have grammatical gender in the L1 cannot process gender concord online in their L2 but, rather, that the conflict posed by the presence of nouns with opposing gender suffices to temporarily outweigh automatic feature checking processes.

*ERP evidence of the link between phonological cues and morphological processing: the case of subject-verb agreement.*
In another recent series of ERP studies, we examined the effects of phonological realization on morphosyntactic agreement for verbal agreement in written French (Carrasco & Frenck-Mestre, 2007, in prep; Frenck-Mestre et al. 2008; 2009; McLaughlin et al., in press).

In a first study (Frenck-Mestre et al., 2008), we recorded ERPs from native French controls and German L1 – French L2 learners while they read one of three types of sentences, illustrated in Table 3. In these sentences, we varied the presence versus absence of oral cues to subject–verb agreement. Based on previous behavioral evidence in both French and Dutch, cited above, and based on our results obtained for gender concord within the DP, we hypothesized that the presence of oral cues should enhance the reader’s likelihood to process morphology and thus to detect and repair errors in the case of mismatched verbal person and verbal inflection. Hence, we predicted a P600 effect to verbal person errors, which should vary in amplitude as a function of the presence of oral cues; phonologically silent verbal person errors should give rise to a smaller P600 effect than orally realized errors.

<table>
<thead>
<tr>
<th>Sentence onset</th>
<th>Correct phonologically realised</th>
<th>Incorrect phonologically realised</th>
<th>Incorrect, phonologically silent</th>
<th>Sentence end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Le matin</td>
<td>je mange</td>
<td>mangez</td>
<td>manges</td>
<td>du pain</td>
</tr>
<tr>
<td></td>
<td>tu manges</td>
<td>mangez</td>
<td>mange</td>
<td></td>
</tr>
<tr>
<td></td>
<td>il/elle mange</td>
<td>mangez</td>
<td>manges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nous mangeons</td>
<td>mangent</td>
<td>manges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vous mangez</td>
<td>manges</td>
<td>manges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ils/elles mangent</td>
<td>mangeons</td>
<td>manges</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Examples of the three sentence conditions (correct, incorrect and phonologically realized, incorrect and silent) for the six different verbal persons in French.

The results of this first study confirmed our general prediction. Native French controls showed a robust P600 to all subject-verb agreement errors, but a statistically larger effect in the case of phonologically realized inflectional errors. Hence, the native French showed sensitivity to phonological cues to inflectional morphology within the IP, in like manner to the
results obtained for gender concord within the DP (Carrasco & Frenck-Mestre, 2007, 2009; 2010; in prep; Frenck-Mestre et al., 2009). For German L1 learners of French, sensitivity to inflectional errors also varied as a function of whether they were orally realized or not, but not in the same way as for native French controls. For the L2 learners, only verbal agreement errors that had a clear oral distinction elicited an ERP response, namely a P600 effect. Silent errors did not elicit any reliable widespread response in the L2 group. The interpretation of a lack of a response to silent inflectional errors in the L2 group is open however, we believe it most likely, given the nature of electrophysiological responses to linguistic stimuli and the by definition heterogeneity of L2 learner groups, that the best interpretation is that in the absence of an oral cue to an error not enough participants and not enough trials elicited an ERP response to become visible in the grand average. It is possible that with more trials and/or participants that we would have obtained an automatic brain response to these errors in the L2 group. Notwithstanding, the main result that can be retained from this study is that both native speakers and L2 learners are more sensitive to the orthographic manifestation of inflectional morphology when these inflections are also orally realized.

We have since replicated the effect of phonological recoding on written verbal agreement errors in two subsequent ERP experiments, using the same materials but with different participant populations (McLaughlin et al., in press; Carrasco & Frenck-Mestre, 2007, in prep). In the first of these replications (Carrasco & Frenck-Mestre, 2007, in prep) we examined Spanish L1 learners of French as well as a group of French controls. Overall, the pattern of results is in agreement with the pattern reported above. French native controls showed a P600 response to inflectional errors, which was statistically larger in the case of orally realized errors. For the Spanish-French learner group, however, and as was the case for our German L1 – French L2 group, while inflectional errors were processed online as attested by a robust P600 response to these violations, the influence of the oral manipulation was not
as clear. For the L2 group, the difference in the ERP response to orally realized and silent errors was less pronounced and reduced in distribution across the scalp in comparison to that obtained than in the native French group.

Closer inspection of the ERP data for the native French and L2 French groups revealed a further difference. In both the native and non-native group, the ERP response to inflectional errors was not identical for the plural and singular verbal person, and the effect of verbal number differed in the two groups. For the native French group, as illustrated in Figure 1a and 1b, the effect of violating verbal agreement was in fact much larger for the first and second person plural (“nous” and “vous”) than for the three singular persons (“je”, “tu” and “il/elle”). In the Spanish L1 – French L2 group, the opposite was true. In this group, for the three singular persons, a large P600 effect was elicited by verbal agreement errors, which was statistically larger for orally realized than silent errors; for the first and second person plural, no reliable effect of inflectional errors was observed. These effects are visible in Figure 2a and 2b.

Figures 1a and 1b about here

Figures 2a and 2b about here

The design of our study unfortunately renders the discussion of the above differences rather tricky. Indeed, although there were an equal number of trials for the three inflectional conditions (correct, orally realized and silent errors) an equal number of each of the six verbal
persons could not be included in all conditions. Violations of verbal concord for the first and second person plural—“nous” and “vous”—are systematically orally realized and hence could not be included in the silent condition. Thus, when we consider the conditions independently for the different verbal persons, there were far fewer trials for the plural (nous and vous) than for the three singular (je, tu and il/elle). It is indeed possible that the lack of an ERP response in the L2 group for the violation of the pronouns “nous” and “vous” is a combined result of the small number of trials and overall greater heterogeneity of response in the L2 group. Nonetheless, the results are revealing in that, in the French native group, the strongest cortical response to inflectional violations was found for the most regular patterns, i.e. for mispairing of verbal inflection for “nous” and “vous.” Both the written and oral inflections for these two pronouns are highly regular, across verb class, tense and aspect. Indeed, production errors for these inflected forms, whether written or oral, are very rare. One could hypothesize that, given the regularity of these forms and the clear presence of an oral cue to morphology, that they would be grammaticalized fastest for L2 learners. Our data do not support this hypothesis.

In a final study (McLaughlin et al., in press), native English speakers were studied longitudinally. The aim was to determine whether the presence of phonological cues facilitates the learning of morphosyntactic agreement during the earliest stages of second language acquisition. Indeed, both the L1 German learners studied by Frenck-Mestre et al. (2008) and the L1 Spanish learners studied by Carrasco & Frenck-Mestre (2007, in prep) had had several years of instruction in their L2 and were living in France and following a university curriculum in the French language at the time of their participation. It was thus of interest to determine what the effect of these oral cues might be at earlier stages of acquisition. Learners were tested in three consecutive sessions: after approximately three months, six months, and nine months of French instruction, Sessions 1, 2, and 3, respectively.
Intriguingly, and as reported in previous longitudinal studies of L2 acquisition (Osterhout et al., 2004; 2006) the L1 English L2 French learners showed striking individual differences in their ERP responses. Thus, using an adapted procedure (cf. McLaughlin et al.), the learners were separated into two groups (“N400 group” and “P600” group) based on their ERP responses recorded during the third session. For the N400 group, no significant ERP differences were observed between the well-formed and ill-formed sentences during the first two sessions. However, by Session 3, after approximately 9 months of instruction, this group of learners showed an N400 effect to the morphosyntactic errors. By contrast, the P600 group showed no reliable ERP effects during Session 1, an N400 response to inflectional errors during Session 2, and by Session 3 the N400 effect was replaced by a small P600 effect.

Interestingly, no reliable ERP differences between the phonologically realized and phonologically silent errors were observed during any of the testing sessions for either L1 English group. However, while we did not observe an effect of phonological realization in the learners’ ERPs, we did see differences in their acceptability judgments to these items. Learners were more accurate at identifying the inflectional errors when those errors were phonologically realized (mean d-prime, averaged across sessions = 2.7, SE = .21) than when they were phonologically silent (mean d-prime, averaged across sessions = 2.1, SE = .18). This suggests that in learners the processing of the orthographic input may not have triggered a simultaneous activation of phonological information, as it seems to have with native speakers and more proficient learners. Rather, the learners apparently used phonological information later during processing in order to make well-formedness decisions about the sentences. The presence of phonological cues, therefore, does seem to have some effect on the learning of grammatical morphemes in the early stages of acquisition, at least as indexed by the learners’ behavioral performance.
Overall, this series of ERP experiments examining the online processing of verbal agreement corroborates our findings for the online processing of gender concord in showing a robust effect, in native speakers, of oral cues to morphological variation. The effect is also found for L2 learners, from various language backgrounds, however the effect was systematically smaller in the L2 learner groups and sometimes found in behavioral measures rather than in the ERP trace. In addition, the L2 learners differed from native speakers in that the learners were apparently not yet as sensitive to the regularity of inflectional patterns as native speakers were, again, as revealed by differences in the immediate cortical response to different types of violations.

**General discussion**

The present paper set out to examine the influence of input factors on L2 online grammatical processing, and how these factors might differentially affect L2 learners’ and native speakers’ processing. We reported the data from a series of ERP experiments conducted in our laboratory and in collaboration with others, which examined both nominal gender concord and verbal agreement, in written French. All of these studies clearly demonstrate the influence of one of these factors, namely the presence of phonological cues to agreement.

A first question is whether these phonological cues act to enhance learning. The results from the various studies presented here do not provide strong evidence of this. In the one study where participants were followed longitudinally (McLaughlin et al., in press), the presence of oral cues to verbal inflections did not influence the online processing as evidenced in the ERP response to violations. This was true, moreover, despite striking differences in the brain’s response to grammatical violations as a function of L2 proficiency. Even the more advanced L2 learners, who showed the classical P600 effect by the end of the
nine month learning period did not show a differential response, in either the amplitude or distribution of the P600. In the group of learners who advanced less quickly, showing only an N400 effect in response to morphosyntactic errors even after nine months of instruction, the effect of the oral realization of errors was no more apparent. In both groups, the effect of these phonological cues was only witnessed in the offline behavioral response, i.e. late in processing.

The hypothesis that phonological cues to inflectional morphology might accelerate the learning of these inflections is also partially ruled out by the ERP data for the group of more advanced L2 French learners whose native language was Spanish. These learners did show a differentiated cortical response to errors of verbal agreement as a function of whether these violations were silent or orally realized, in like manner to native French controls. However, the pattern of the ERP response in the L2 group did not indicate that more consistent phonological-morphological pairings (i.e. for “nous” and “vous”) were learned faster. This result should nonetheless be considered with considerable caution. Indeed, the reported experiment was not intended to examine this fine a grain. Materials were such that the topic could be addressed, however, the main thrust of the experiment was to compare the brain’s response to inflectional errors as a function of whether orally realized or silent, not as a function of a given inflection. Further investigation, with a direct manipulation of this variable is necessary to provide a definitive answer, thus.

The second question of interest is whether the presence of oral cues influences processing similarly in L2 learners and native speakers. Once again, the answer is apparently negative, although we will argue that differences are quantitative rather than qualitative. In all of the experiments involving verbal agreement (Carrasco & Frenck-Mestre, 2007, in prep; Frenck-Mestre et al., 2008; McLaughlin et al., in press) and in the majority involving nominal gender concord (Carrasco & Frenck-Mestre, 2009, 2010, in prep; Frenck-Mestre et al., 2009),
the effect of phonological cues on processing was reduced or, in the most extreme case absent, compared to that of native speakers, as evidenced by the amplitude of the brain’s immediate response to violations. This result is in fact not surprising, given the results of numerous studies which compared readers of different reading skill. The common consensus from these studies is that less skilled adult readers are less efficient at using phonological codes. This has been shown both in studies of isolated word recognition (Greenberg, Ehri & Perin, 2002; Pratt & Brady, Thompkins & Binder, 2003; Unsworth & Pexman, 2003) and, more germane to the present topic, in studies of online sentence processing in which eye movements were recorded during silent reading (Binder & Borecki, 2008; Chace, Rayner & Well, 2005; Rayner et al., 1998). While these studies have examined the relative weight of orthographic to phonological codes for spelling variations and not for inflectional morphology, they nonetheless share the common underlying finding that reading involves the activation of phonological codes, and more so in skilled readers. Our results, using ERPs as the online measure, corroborate this finding if one accepts the hypothesis that L2 learners are less efficient in general at processing their second language than are native language controls.

The last question, which, as outlined in the introduction is yet a topic of intense debate, concerns the necessity to activate phonological codes during the processing of a written word. The data from the numerous ERP experiments we have conducted so far certainly attest to the widespread effect phonological recoding during the processing of syntactic agreement, both in the native language and, in reduced measure, in second language processing. As such, at the least we can make the claim that these codes are indeed part and parcel of processing, be it for lexical retrieval or the calculation of grammatical relations. The present results thus complement a growing body of research showing the importance of this factor, and shed new light on the factors that affect the online processing of a second language.
References


FIGURE 1A.
FIGURE 1B.
Figure 2A.
FIGURE 1A. P600 effect to verbal agreement errors in written French, for the three singular persons as a function of condition (top line = correct inflection, middle = silent error, bottom = orally realized error) in the group of native French controls.

FIGURE 1B. P600 effect to verbal agreement errors in written French, for the 1st and 2nd person plural as a function of condition (top line = correct inflection, bottom = orally realized error) in the group of native French controls.

FIGURE 2A. P600 effect to verbal agreement errors in written French, for the three singular persons as a function of condition (top line = correct inflection, middle = silent error, bottom = orally realized error) in the group of Spanish L1 – French L2 learners.

FIGURE 2B. ERP response to Correct (top line) and Infelicitous (bottom line) verbal agreement conditions in written French, for the 1st and 2nd person plural in the group of Spanish L1 – French L2 learners.
In French, singular definite determiners are not specified for gender when the noun has an initial vowel due to the process of elision. Moreover, differences in gender agreement arise between French and Spanish when the plural is considered, for which Spanish specifies gender in the definite determiner but French does not.