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The effect of phonological realization of inflectional morphology on verbal agreement in French: Evidence from ERPs

Cheryl Frenck-Mestre [a,*], Lee Osterhout [c], Judy McLaughlin [c], Alice Foucart [a,b]

[a] LPL, UMR 6057 – CNRS, Aix-Marseille University, 29 Avenue Robert Schuman, 13621 Aix-en-Pce, France
[b] Department of Psychology, University of Edinburgh, 7 George Square, Edinburgh EH8 9JZ, Scotland
[c] Department of Psychology, Box 351525, University of Washington Seattle, WA 98195, USA

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Abstract

The present study examined the impact of the phonological realization of morphosyntactic agreement within the inflectional phrase (IP) in written French, as revealed by ERPs. In two independent experiments, we varied the presence vs. absence of phonological cues to morphological variation. Of interest was whether a graded ERP response to these different conditions could be found in native speakers (Experiment 1), and whether non-native learners would benefit from the presence of phonological cues (Experiment 2). The results for native French speakers showed that compared to grammatically correct instances, phonologically realized inflectional errors produced a significant P600 response, which was statistically larger than that produced by errors that were silent. German L1–French L2 learners showed similar benefits of the phonological realization of morphemes. Phonologically realized errors produced a robust P600 response whereas silent errors produced no robust effects. Implications of these results are discussed in reference to previous studies of L2 acquisition of morphosyntax.
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1. Introduction

Fully mastering a foreign language that is learned after childhood is a feat that few individuals achieve. As illustrated in studies of adults who are highly proficient in their second language and are considered by native speakers to be "near-native", sensitive-enough measures of linguistic competence generally show that these individuals are still found to be lacking in comparison to individuals who were raised in the language (Sorace, 2003; Sorace & Filiaci, 2006). It is not surprising that the areas of linguistic competence where even "near-natives" fall short of native competence are those where the beginning adult second-language acquirers experience difficulty; that is, where the native and second language differ as concerns grammatical categories and/or how their features are parameterized (cf. Herschensohn, 2004, for a review). Whether the absence of a grammatical feature in the native language actually precludes attainment of this feature in the second language or only retards its development has been the topic of substantial and on-going debate (Hawkins & Franceschina, 2004; Herschensohn, 2000; Schwartz & Sprouse, 1996; White, 2003; White, Valenzuela, Kozlowska-MacGregor, & Leung, 2004). The present paper is an attempt to determine some of the factors above and beyond shared features that may play a role in acquiring second language grammatical competence. In particular, we will look at the co-variation between morphology and phonology, and how such may influence learning. More specifically, we will

* Corresponding author. Tel.: +33 442953746; fax: +33 442953788.
E-mail address: Cheryl.Frenck-Mestre@univ-provence.fr (C. Frenck-Mestre).

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examine how phonological cues may impact the readers' processing of verbal inflection, both in a second language and in comparison to skilled native readers.

Various recent studies have examined second language grammatical attainment in adult learners using event-related potentials as the measure of interest (cf. Frenck-Mestre, 2005; Mueller, 2005; Osterhout, McLaughlin, Pitkanen, Frenck-Mestre, & Molinaro, 2006, for recent reviews). Such shall be the method adopted here. Indeed, ERPs not only provide a rich on-line measure of linguistic processing, but recent work has also demonstrated that they are both capable of evidencing sensitivity to some form of lexical processing in the early stages of second language attainment in the absence of conscious knowledge (McLaughlin, Osterhout, & Kim, 2004) and suggested that they can reveal qualitatively different stages of the grammaticalisation process (Osterhout, McLaughlin, Kim, & Inoue, 2004). As a consequence, ERPs would seem to be the ideal tool for investigating different stages of (second) language attainment and the factors that influence it.

The results from both off-line studies and reaction time paradigms have suggested that although the native language may influence the acquisition and learning rate of morphosyntax in a late-acquired language, it is clear that difficulties cannot be ascribed solely to this factor, as the same pattern of difficulty in acquisition has been observed whether the to-be-acquired feature is specific to the L2 or not (McDonald, 2000; White et al., 2004; see also Sato & Felser, 2006). Relatively few ERP studies have directly addressed this topic and even fewer have looked at the early stages of acquisition. Two exceptions to this rule are the studies by Tockowitz and MacWhinney (2005) and Osterhout et al. (2004, 2006). In both studies, the acquisition of different features of verbal and nominal agreement in a second language (Spanish or French) was examined in novice adult learners whose first language was English. Both studies found that nominal number concord errors failed to produce reliable differences in the ERP trace as compared to correct instances: in short, visually presented L2 sentence contexts. This was true even though Osterhout et al. tested the same participants longitudinally at three intervals, the longest being after several months of instruction, and despite there being learners with several months of instruction in the Tockowitz and MacWhinney study as well. For violations of tense in the L2, Tockowitz and MacWhinney (2005) reported a P600 effect, although the effect was both small and showed a rather atypical and reduced distribution. For verbal agreement violations in the L2, Osterhout et al. (2004, 2006) reported longitudinal changes, with an initial N400 effect to these errors that morphed into a P600 effect with increased proficiency, again in the same longitudinal design thus reducing inter-individual variability and allowing for much closer inspection of learning patterns. The final pattern of the two studies is nonetheless similar; no effect nominal number agreement violations in the L2 and an end-state P600 effect for verbal violations. The authors of both studies suggested that one factor driving the results was the presence of similar versus divergent features of morphosyntax across the native and second languages; both French and Spanish have nominal number agreement such that determiners and adjectives must agree in number with the noun, whereas English has only rare cases in which determiners agree in number with the noun ("these", "those"). All three languages, however, share the common features of tense and verbal agreement, even if the morphological marking of verbal agreement is greatly reduced in English as compared to French and Spanish. In light of these results Osterhout et al. (2004, 2006) as well as Tockowitz and MacWhinney (2005) suggested that faster learning would be expected for verbal than nominal agreement.[1]

Differences in sensitivity to nominal and verbal morphosyntactic violations, as evidenced by ERPs, have also been found in the L2 for more proficient learners, and for whom the native and second language share the same grammatical features (Hahne, Mueller, & Clahsen, 2006). Hahne et al. (2006) found that violations of the regular participle formation in German produced both an anterior negativity and a P600 effect in native Russian speakers, whereas violations of the regular plural formation for German nouns produced a P600 effect in the absence of any earlier response for these learners. From their results, they argued that while automatic processes of morphological decomposition are used by L2 learners of German for participles, they are not involved in the processing of plural nouns for non-native speakers, due to the complex nature of plural formation in German which takes longer to master than participle formation (cf. also Parodi, Schwartz, & Clahsen, 1997). Note that this line of argumentation is based upon the premise that anterior negativities are an index of automatized grammaticalization processes, whereas the P600 would be a marker of revision processes, which is not unanimously accepted (cf. Coulson, King, & Kutas, 1998; Friederici, Hahne, & Mecklinger, 1996; Krott, Baayen, & Hagoort, 2006; Osterhout & Hagoort, 1999). Nonetheless, the results of Hahne et al. (2006) concur with those of Tockowitz and MacWhinney (2005) and Osterhout et al. (2004, 2006), showing slower learning rate of nominal than verbal inflection.

Herein, we chose to concentrate on verbal inflection and its attainment in the L2. More specifically, our study was designed to determine whether sensitivity to verbal agreement in written French is affected by the co-variation between morphology and phonology. In both the Osterhout et al. (2006) and Hahne et al. (2006) studies, it was suggested that the presence of phonological cues and/or the

[1] Tockowitz and MacWhinney also found that English native speakers were sensitive to gender concord errors in Spanish, even though grammatical gender is absent in English. They suggest that features that are absent from the native language should in fact be acquired faster than those that are in conflict (or "competition") with second language parameters, such as the case of nominal number concord in English vs. Spanish.

regularity of phonological variation may also have been responsible for differences in sensitivity to morphological violations. Indeed, studies of both non-native and native readers have suggested that the presence of phonological cues leads to faster learning of morphological rules and more stable representations of these rules. Arteaga, Herschensohn, and Gess (2003) have suggested that a thorough grounding in L2 phonological patterns is essential for language learners, and present evidence of the importance of phonological information for the acquisition of morphological form in French. Their results, obtained in a classroom setting, showed that English native speakers acquire nominal gender concord (between a noun and an adjective) faster when they are first taught phonological variations of the masculine and feminine forms of variable adjectives than when more traditional instruction on spelling variation is emphasized (i.e. "add" an "e" to the feminine). Behavioral studies involving native speakers of both French (Largy & Fayol, 2001; Negro & Chanquoy, 2000) and Dutch (Frisson & Sandra, 2002; Sandra, Frisson, & Daems, 1999) have shown, as well, that fewer inflectional errors in written language (for both verbal and nominal numbers) are observed for phonologically realized morphemes than for silent morphemes, both during development (Frisson & Sandra, 2002; Negro & Chanquoy, 2000) and in skilled adults[2] (Largy & Fayol, 2001; Sandra et al., 1999).

The present study is a natural extension of the above-cited studies in that we examined how phonological cues may aid in processing written French during reading. Indeed, anyone who has tackled the problem of learning French has encountered the difficulties posed by the absence of phonological cues to morphemic variation. French has a largely silent morphology, with a many-to-one mapping between morphemic inflections and phonemes. For example, in written French, regular verbs have five different inflections for the six verbal persons but only three phonological forms such that there is no audible distinction between inflected forms for the three singular persons or between these forms and the third person plural (cf. Table 1). Moreover, this is true across tenses for regular verbs. Hence, the oral sentences "Ils mangent du poisson" (*They eat fish*) and "Il mange du poisson" (*He eats fish*) are phonologically identical and can only be distinguished on the basis of context. Moreover, the plural morpheme –s is silent in the vast majority of cases (Dubois, 1965), such that there is no oral cue to the distinction between singular and plural nouns, pronouns and adjectives on the whole. In French, all elements of the determiner phrase (DP) must agree in number (and gender), with plurality being marked for all elements by grammatical morphemes, however only variations in the determiner are audible such that the oral phrases "les petits chiens blancs" and "le petit chien blanc" (the little(s) white(s) dog(s)) vary by only one phoneme.[3] As shown in developmental studies (Negro & Chanquoy, 2000), and under stressed conditions in adult writers (Largy & Fayol, 2001), the absence of phonological cues is manifested by a concomitant absence of morphological marking of the plural.

The aim of the present study was to determine the impact of phonological realization on the processing of verbal inflection in written French, both in native controls and in German-L1 French-L2 learners. This study is a direct extension of previous research (Osterhout et al., 2004, 2006) in which the overlap of grammatical features in the native and second language and phonological realization were confounded, thus leaving open the possibility that either, or a combination of both, could explain differences in learning rate. Herein, we varied the presence versus absence of oral cues to subject–verb agreement in short sentences, as illustrated in Example 1 and in Table 2. We can hypothesize, based on previous behavioral evidence in both French and Dutch, cited above, that the presence of oral cues should enhance the reader's likelihood to detect and repair these errors. In line with the previous ERP research, one might predict variations in the amplitude of

Table 1
Orthographic and phonological transcription of the six verbal person variations in French

Singular		Orthography	Phonology
1st	je (I)	mange (eat)	manʒə
2nd	tu (you)	manges	manʒə
3rd	il/elle (s/he)	mange	manʒə
Plural			
1st	nous (we)	mangeons	manʒõ
2nd	vous (you)	mangez	manʒe
3rd	ils/elles (they)	mangent	manʒə

Table 2
Examples of the three sentence conditions (correct, incorrect and phonologically realized, incorrect and silent) for the six different verbal persons in French

Sentence onset	Correct	Incorrect, phonologically realised	Incorrect, phonologically silent	Sentence end
Le matin je	mange	mangez	manges	du pain
Le matin tu	manges	mangez	mange	du pain
Le matin il/elle	mange	mangez	manges	du pain
Le matin nous	mangeons	mangent		du pain
Le matin vous	mangez	manges		du pain
Le matin ils/elles	mangent	mangeons	manges	du pain

[2] The question has been raised as to whether the increased difficulty in processing silent suffixes is due to their being silent or, rather, to the fact that they are homophonous with other forms (Sandra et al., 1999). The present study does not allow us to address this issue; however it is indeed one that should be investigated in future studies.

[3] Note that an exception to the rule is that of nouns and verbs that begin with a vowel, in which case differences between the singular and plural are audible due to the process of liaison.

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the P600 response and/or early negativities (E/LAN effect) to these errors as a function of oral cues, for native speakers of French. If the presence of these cues is important inasmuch as acquisition of grammatical morphemes in an L2 is concerned, we can also hypothesize an earlier response to orally realized errors than to silent errors in L2 learners. Both hypotheses were tested herein.

1. Le matin je $\mathbf{mange}_{1st,sing}/\mathbf{manges}^{*}_{2cd,sing}/\mathbf{mangez}^{*}_{2cd,sing/plur}$ très peu.
In the morning ***I eat***/$\boldsymbol{eats}_{2cd}$/$\boldsymbol{eat}_{2cd}$ *very little.*

2. Experiment 1

2.1. Method

2.1.1. Participants

Fifteen native French speakers (7 female) aged 20–24 years (mean age 21.5 years) enrolled at a French university participated for monetary compensation. All subjects were dominant right-handed with normal or corrected-to-normal vision. All participants had learned English as a second language throughout their secondary school, although their fluency in this language was not tested. One participant was later dropped from analyses due to excessive movement during the experiment.

2.1.2. Materials

Experimental stimuli consisted of ninety, single clause, declarative sentences created from materials in the first five chapters of an introductory French textbook. These sentences were used in three different syntactic conditions, defined by subject–verb agreement. Across the 90 experimental sentences, 20 regular, first-group ("er") French verbs were used, each verb being presented either 4 or 5 times. Three syntactic conditions were created by manipulating the pairing of different verbal inflections with a given verbal person, with 30 sentences per condition: correct (e.g. "je mange"), incorrect and orally realized (e.g. "je mangez"), and incorrect and silent (e.g. "je manges"). Examples are provided in Table 2. All verbs were seen in all conditions and all six verbal persons were used. The three singular persons ("je", "tu" "il/elle") and the third person plural ("ils/elles") were seen in each of the three syntactic conditions, while the first and second person plural ("nous" and "vous") were seen in only the correct and incorrect orally realized conditions, given that for these pronouns any mispairing of verbal inflection in the present indicative results in a phonologically realized error. Three lists were created such that test sentences were rotated across lists, with each occurring only once per list and in a different condition per list. Sentences ranged in length from 5 to 10 words. The position of the critical verb varied across sentences, from the second to the fifth word, but was never the last word. The critical verb always immediately followed the pronoun (indeed, any other position would have resulted in grammatical error). Sixty other sentences with irregular verb forms, half involving syntactic errors, were also presented, these being materials for an embedded experiment. Forty-five additional filler sentences that did not involve syntactic anomalies (15 involved semantic anomalies) were added to distract the participants' attention from the syntactic manipulation. In total, each stimulus list contained 90 experimental plus 105 filler sentences. Each participant saw only one list, with a different random order of presentation of sentences created for each participant.

2.1.3. Procedure

Participants read sentences concurrent with ERP recording. Sentences were displayed visually on a computer monitor. Each trial sequence consisted of the following: a fixation cross (500 ms) followed by the stimulus sentence, which was presented one word at a time, each word being displayed for 450 ms followed by an 150 ms blank-screen (600 ms inter-stimulus interval) followed by a yes/no prompt. Participants read for comprehension and made meaning-acceptability judgments at the prompt after each sentence by means of a press on one of two buttons (right or left) on a button box to indicate whether or not the sentence was acceptable.

EEG activity was recorded continuously from 21 scalp locations, using tin electrodes attached to an elastic cap (Electrocap International). Scalp sites included standard International 10–20 locations of the left and right hemispheres over pre-frontal (Fp1, Fp2), frontal (F3, F4), inferior-frontal (F7, F8), central (C3, C4), posterior-temporal (T5, T6), parietal (P3, P4) and occipital (O1, O2) areas as well as from three midline sites (Fz, Cz, Pz). In addition, electrodes were placed centrally between homologous inferior-frontal and central sites (Fc5, Fc6), and central and parietal sites (Cp5, Cp6). Two additional electrodes were used to monitor for horizontal and vertical eye movements. All electrodes were referenced to the left mastoid. The EEG was amplified with a band pass of 0.01–100 Hz (3 dB cutoff) by means of an SAI bioamplifier system. Epochs began 100 ms prior to stimulus onset and continued 1100 ms thereafter. Average ERPs were calculated off-line from trials free of artifacts (less than 7% of rejections per condition overall). Averaging was performed without regard to behavioral responses.

2.1.4. Data analysis

Behavioral responses to semantically anomalous distracter sentences and to test sentences in the three syntactic conditions were quantified. The ERP data were quantified by calculating the mean voltage amplitudes and peak latencies (relative to a 100 ms pre-stimulus baseline) in four time windows: 50–150, 150–300, 300–500 and 600–800 ms post stimulus-onset. These windows correspond to those associated with the N1, P2, N400 and/or LAN, and P600 components respectively, which are frequently observed in the studies of visual processing of linguistic stimuli. Data acquired at midline and lateral sites were treated separately. At midline, a two-way repeated measures ANOVA was performed, with three levels of sentence type (correct, orally realized verbal concord error and silent verbal concord error) and three levels of electrode (frontal, central and parietal). At lateral sites, two independent three-way ANOVAs were performed on the data, with repeated measures on sentence type, two levels of hemisphere (left and right) and either three levels of electrode for anterior sites (frontal, inferior-frontal and frontal-central) or 4 levels of electrode for central-parietal sites (central, central-parietal, parietal and posterior-temporal). The Greenhouse-Geisser (1959) correction was applied to all repeated measures with greater than one degree of freedom. All significant differences involving more than two conditions were confirmed by post-hoc comparisons.

2.2. Results

The analysis of behavioral results for semantic acceptability judgments revealed ceiling level accuracy (98.6%). No participant failed to reject more than two sentences containing semantic anomalies and the majority of participants rejected all. Test sentences in the three syntactic conditions were accepted in the great majority of cases and did not differ as a function of condition (98.6%, 97.6% and 98.6% for correct, incorrect and phonologically realized, incorrect and silent).

Grand-average ERPs to the critical verbs for all electrodes are shown in Fig. 1, in which waveforms to correctly inflected verbs, silent verbal concord errors and orally realized verbal concord errors are plotted. As is visible, a clear N1–P2 complex was evoked in the first 300 ms following critical word onset, for all conditions. Beginning around 550 ms and persisting until 800 ms or beyond, verbal concord errors provoked a positive deflection in comparison to correctly inflected verbs, with a peak at roughly 600 ms, generally described as a P600 effect. This pattern was true for both orally realized and silent errors with a larger effect for the former.

Statistical analyses revealed no reliable differences across conditions in the first 300 ms following critical verb onset, nor were there any reliable differences between conditions in the 400–600 ms window. In the 600–800 ms window, a main effect of stimulus type was observed [midline, ($F(2,26) = 7.28$, $p < .005$); posterior lateral ($F(2,26) = 8.84$, $p < .001$). The effect of stimulus type was more pronounced at posterior sites, resulting in an interaction between stimulus type and electrode site [midline, $F(4,52) = 11.25$, $p < .001$; anterior lateral, $F(4,52) = 4.13$, $p < .01$; posterior lateral, $F(6,78) = 2.65$, $p < .05$]. At midline, post-hoc comparisons (Tukey) showed that orally realized and silent verbal concord errors both differed from control sentences at all three midline sites ($p < .01$ or better, for all comparisons) and from each other at central (Cz, $p < .01$) and

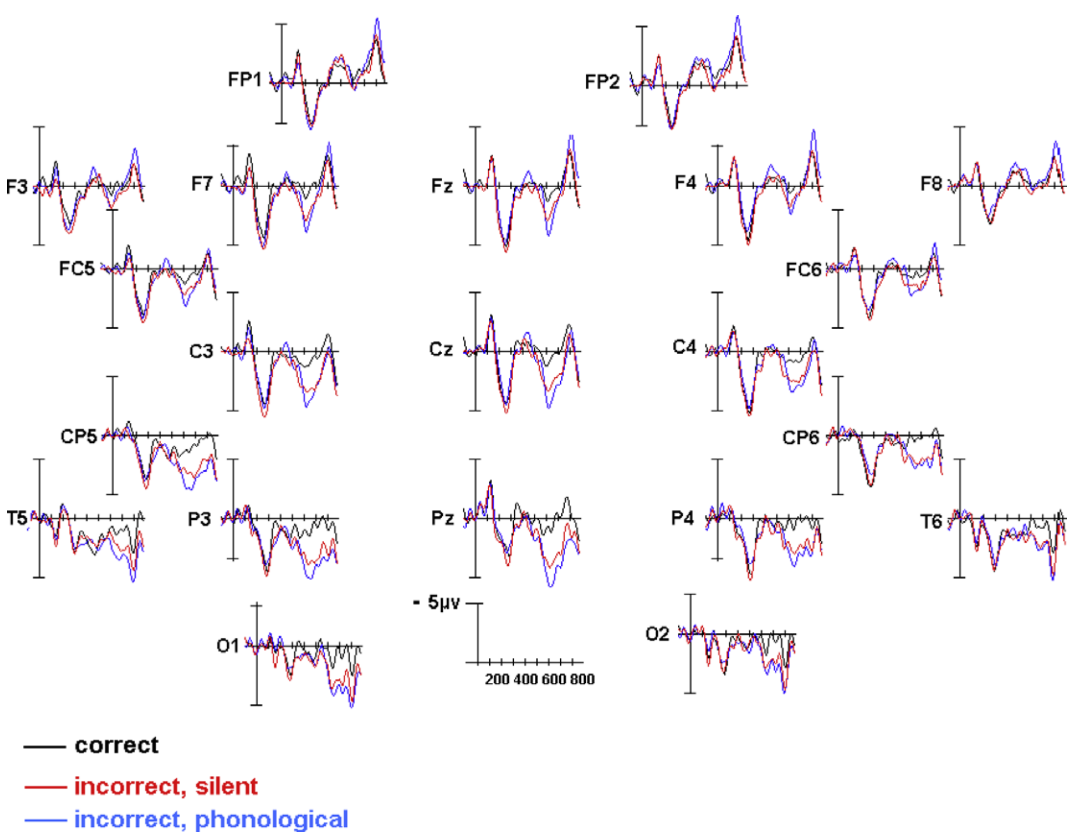

Fig. 1. Grand mean averages for native French participants as a function of inflectional condition (correct, incorrect orally-realized and incorrect silent) and electrode site.

parietal (Pz, $p < .001$) sites, with a larger P600 effect for orally realized than for silent errors. The difference between silent and orally realized errors at midline was also confirmed by an independent ANOVA, which showed a significant interaction between stimulus type and electrode site ($F(2,26) = 4.09$, $p < .05$) due to a larger P600 effect for orally realized than silent verbal concord errors at central ($p < .005$) and parietal ($p < .001$) sites but not frontally. At lateral sites, post-hoc comparisons confirmed reliable differences between control and both orally realized and silent errors which did not differ from each other.

2.3. Discussion

The results from the first experiment show a clear P600 effect to morphosyntactic violations in native speakers, as could be expected from the literature on syntactic processing of visually presented sentences (Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992). We did not find any earlier effects. Our main intention was to determine whether oral cues to these orthographic morphosyntactic violations would enhance the P600 effect in comparison to silent errors. Our results provide evidence of this. A reliably larger P600 effect was found at central and parietal midline sites for verbal concord errors that were phonologically distinct from correct inflections (e.g. je mangez* vs. je mange) than for silent verbal concord errors (e.g. je manges* vs. je mange). The difference in the size of the P600 effect was small, nonetheless, and was not reliable at lateral sites.

Our data suggest, first, that during normal reading the type of phonological cue that we manipulated may play a relatively small role in proficient adult readers when reading in their native language. The debate is open, at present, moreover, as to what the P600 actually indexes (Coulson et al., 1998; Friederici et al., 1996; Kim & Osterhout, 2005; Osterhout & Hagoort, 1999), such that the effects we found may exert their influence in re-analysis rather than in immediate syntactic checking mechanisms. The presence of even a limited effect of phonological factors on syntactic processing hints nonetheless at the possibility that the presence of oral cues to morphosyntactic errors in written language may provide a handle for the detection of these errors. The influence of this factor may also differ depending upon reading skills (cf. Frisson & Sandra, 2002; Negro & Chanquoy, 2000). The aim of Experiment 2 was to test precisely this, i.e. to determine whether oral cues to verbal concord errors would produce enhanced and/or differential effects in late bilingual readers, reading in their second language.

3. Experiment 2

3.1. Method

3.1.1. Participants

Ten German–French speakers (6 female) participated. All were classifiable as "late bilinguals", having learned French during secondary school (mean age of acquisition of French, 14.5 years, and mean years of study of French, 6 years). All had passed a standardized test of French as a second language to gain admittance to French university, and were following a university curriculum in the French language and were living in France (mean of 6 months) at the time of participation. All were thus relatively advanced in their second language and substantially more so than that of those studied by Osterhout et al. (2004, 2006), but roughly comparable to the population studied by Hahne et al. (2006). All nonetheless rated themselves as strongly L1 dominant in all aspects of language processing. All participants had also learned English as a foreign language throughout their secondary school, although their fluency in this language was not tested.

3.1.2. Materials

The materials were those from Experiment 1.

3.1.3. Procedure

The procedure was identical to that of Experiment 1.

3.1.4. Data analysis

This was identical to Experiment 1 with the exception that the N400 time window was shifted to 400–600 ms, based both on visual inspection and prior on research in the L2 literature often showing a delay in N400 effects in the second language (cf. Kotz, 2001, for a discussion).

3.2. Results

The analysis of behavioral results for semantic acceptability judgments revealed ceiling level accuracy (96%). No participant failed to reject more than two sentences containing semantic anomalies and the majority of participants rejected all. Test sentences in the three syntactic conditions were accepted in the great majority of cases and did not differ as a function of condition (97.7%, 94.3% and 95% for correct, incorrect and phonologically realized, incorrect and silent).

Grand-average ERPs to the critical verbs for all electrodes are shown in Fig. 2, in which waveforms for correctly inflected verbs, orally realized verbal concord errors and silent verbal concord errors are presented. A clear N1–P2 complex was evoked in the first 300 ms following critical word onset, for all conditions. In comparison to correctly inflected verbs, orally realized verbal concord errors provoked a positive deflection beginning at approximately 600 ms and persisting until roughly 800 ms or beyond, with a peak at roughly 600 ms, in line with a P600 effect. For silent verbal concord errors, a negative deflection in the 400–600 ms time window was observed.

Statistical analyses revealed no reliable differences across conditions in the first 300 ms following critical verb onset. Differences were observed, however, both in the N400 and P600 time windows, which differed for the two types of verbal concord errors.

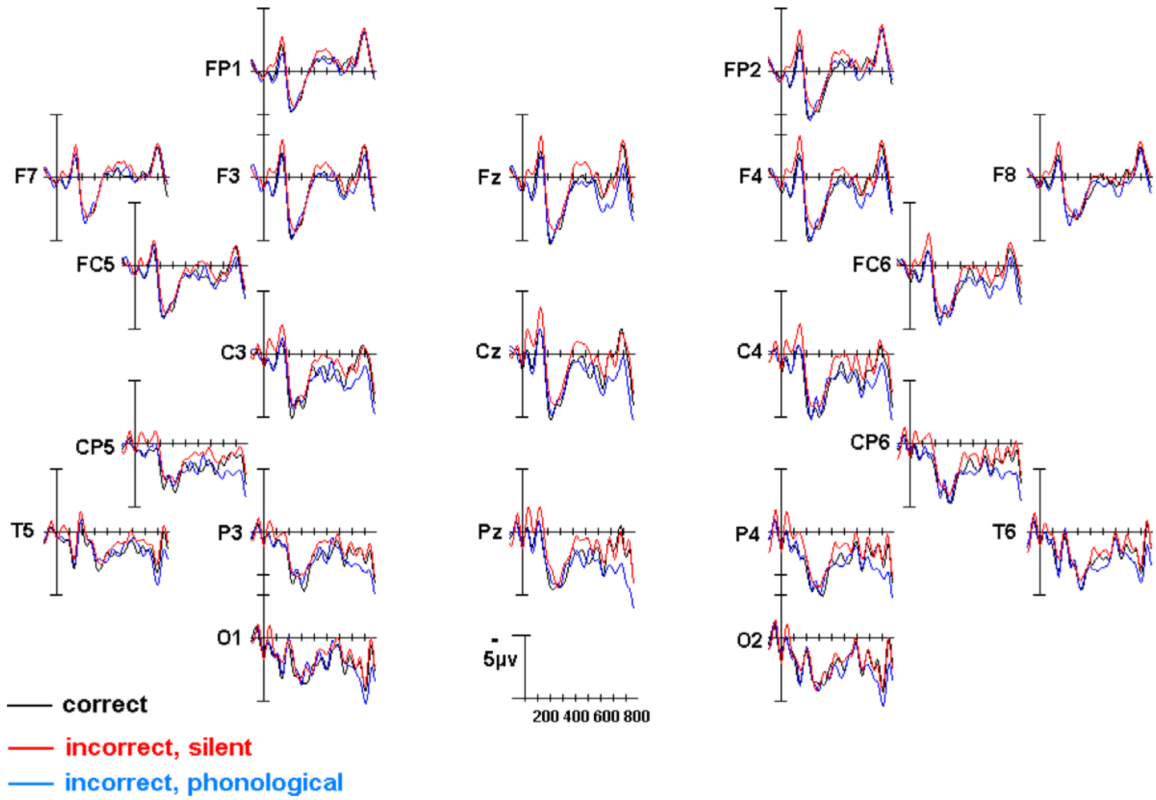

Fig. 2. Grand mean averages for German L1 French L2 participants as a function of inflectional condition (correct, incorrect orally-realized and incorrect silent) and electrode site.

In the 400–600 ms window, there was a trend for the effect of sentence type [midline, ($F(2,18) = 3.53$, $p < .09$); anterior lateral, $F(2,18) = 2.29$ ns; posterior lateral ($F(2,18) = 3.75$, $p < .08$)]. Post-hoc comparisons (Tukey) showed this trend to be due to a negativity for silent verbal concord errors compared to correct sentences [midline, $p < .06$; anterior lateral $p < .08$; posterior lateral, $p < .04$] and to orally realized verbal concord errors [midline, $p < .06$; anterior lateral, ns; posterior lateral, $p < .05$]. No differences between orally realized errors and correct verbal agreement were found in this time window.

In the 600–800 ms window, a main effect of stimulus type was observed [midline, ($F(2,18) = 12.09$, $p < .001$); anterior lateral, $F(2,18) = 2.27$, $p < .09$; posterior lateral ($F(2,18) = 8.49$, $p < .005$)]. Stimulus type interacted with electrode site at posterior lateral sites ($F(6,54) = 2.59$, $p < .05$) due to larger effects at posterior sites. At midline, post-hoc comparisons (Tukey) showed that orally realized verbal concord errors differed from both control sentences ($p < .001$) and silent verbal concord errors ($p < .001$), which did not differ from each other. The difference between silent and orally realized errors at midline was also confirmed by a test of simple effects, which showed a main effect of stimulus type ($F(1,9) = 20.51$, $p < .001$) due to a large P600 effect for orally realized verbal concord errors in comparison to silent verbal concord errors. At posterior lateral sites, the same pattern was observed, with reliable differences between orally realized errors and both control sentences ($p < .05$) and silent errors ($p < .01$), which did not differ from each. The difference between silent and orally realized errors at posterior lateral sites was also confirmed by a test of simple effects, which showed a main effect of stimulus type ($F(1,9) = 10.26$, $p < .01$).

3.3. Discussion

The results obtained for the group of late L2 learners show, again, a clear P600 effect to morphosyntactic violations.[4] However, in stark contrast to the results obtained with native speakers in Experiment 1, this effect was limited to violations that were phonologically realized. For silent verbal concord errors, no robust effects were obtained.

4. General discussion

The overall pattern of results obtained across Experiments 1 and 2 points to the use of phonological cues to process morphosyntactic markers in French. In both native speakers and non-native learners, phonologically realized morphosyntactic errors elicited a significant P600 response.

[4] Although the P600 effect in Experiment 2 was statistically robust, this effect has a later onset and a somewhat atypical morphology, relative to the P600 effects we have obtained in other studies employing highly similar methods.

It can be noted that neither group showed signs of an earlier anterior negativity when processing these errors; whether or not such is indicative of a lack of early syntactic checking mechanism is open to debate (cf. Krott et al., 2006, for the most recent work on this issue). In contrast to the similarity of response patterns observed to orally realized errors for the two participant groups, silent inflectional errors produced strikingly different patterns of ERP response as a function of whether processed by native speakers or L2 learners. For native speakers, silent inflectional errors elicited a P600 response that was similar in onset and distribution but smaller in amplitude than that elicited by phonologically realized errors. As such, it can be hypothesized that the only real difference in processing for these two types of errors in native speakers was the magnitude of response. For L2 learners, however, silent inflectional errors did not produce any robust effects.

The pattern of results we obtained for our L2 learners is interesting in that it allows us to provide a partial response to a question raised in the Osterhout et al. (2004, 2006) study of English native speakers' acquisition of French. In this study, novice learners showed a faster learning rate for verbal person errors that were phonologically realized than for silent nominal number errors. Our results replicate the P600 effect found for phonologically realized verbal person errors and suggest, moreover, that the faster learning rate of verbal agreement may have been partially due to the presence of oral cues, which were absent in the nominal concord condition. Indeed, our results for silent verbal inflection errors show no robust effects. Note, nonetheless, that we are not claiming that these oral cues to morphosyntactic variations are either necessary for syntactic computation, which would by definition be incorrect, or that they are sufficient in and of themselves to explain differences in learning rate in a second language. Our results do allow us to suggest, nonetheless, that they are one of many factors that play a role in learning.

It should be underlined that the present study examined a group of learners that had already had several years of instruction in their L2 (French), whereas Osterhout et al. used a longitudinal design and initially completely novice learners. Our study does not allow us to determine whether the P600 effect we found in response to orally realized errors was possibly preceded in time by an N400 effect when our participants were in the initial stages of learning their L2. This question is currently being investigated in a longitudinal study (Osterhout et al., in progress).

Both the data obtained in the L2 group and the native control group clearly show that the presence of oral cues enhances grammatical processing in French, as revealed by a robust P600 effect in both groups to inflectional errors that were orally realized, and a larger P600 response to these errors than to silent errors in the native control group. The effect of phonology on syntactic processing has also recently been investigated in an ERP study of grammatical gender in German (Schiller, Munte, Horemans, & Jansma, 2003). Schiller et al. (2003) reported variations in the behavioral data obtained for native speakers, with faster decisions about grammatical gender when either semantic (biological gender) or phonological cues were available. Variations in the ERP response (as indexed by onset and amplitude of the N2OO), however, confirmed only the effect of semantic gender information on accessing syntactic gender information. No reliable differences in the ERP trace were found as a function of whether phonological information could be used to determine syntactic gender.

We should explicitly note that our results presumably reflect the incorporation of L2 morphosyntactic knowledge into the learner's on-line comprehension system. It is conceivable that our learners could have performed very well on other tasks involving phonologically unrealized verbal inflection. Further work on the influence of phonological factors on syntactic learning will provide a fuller picture of how and when L2 inflectional systems are acquired. Nonetheless, the present study provides clear evidence that the phonological status of grammatical morphemes plays an important role both in native processing and in L2 acquisition.

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