Morphosyntax in L1 attrition
While the previous chapters have focused on spontaneous production data, this one is concerned with the processing of L1 structures in bilinguals. In a brief article, the results of an ERP experiment on morphosyntactic violations will be presented. The structures that were used in the experiment include sentences with incorrect grammatical gender marking on determiners. The first two subsections of this chapter will provide a summary of the manifestations of grammatical gender in the world’s languages and a brief overview of how grammatical gender is marked in German.

### 6.1 Grammatical gender crosslinguistically

Published more than twenty years ago, *Gender* by Greville Corbett is still one of the most complete introductions to many relevant facets of grammatical gender (henceforth: GG). The present summary draws on this volume (Corbett, 1991), a more recent article by the same author (Corbett, 2013a) as well as on what Corbett has published online in the *World Atlas of Language Structures* (Corbett, 2013b, 2013c, 2013d).

Grammatical gender (called *noun class* in some linguistic traditions) is a morphological agreement feature: The fact that a noun belongs to a certain GG is reflected in agreeing elements, such as articles, adjectives or verbs. These elements would appear in a different form when combined with a noun belonging to a different class (Corbett, 2013a). Consider the examples (1)–(5) from Chamalal, an unwritten East Caucasian language spoken in Southern Dagestan (Corbett, 1991, sec. 5.1). The noun phrase *hek’wa* ‘man’ is in the genitive and suffixed with a GG-marked element (in boldface), which signals agreement with the following noun phrase. There are five genders; the second and the fifth show identical suffixes in this paradigm:

1. *hek’wa-šu-Ø wac man-GEN-I brother ‘the man’s brother’*
2. *hek’wa-šw-i jac man-GEN-II sister ‘the man’s sister’*
3. *hek’wa-šu-b č’atw man-GEN-III horse ‘the man’s horse’*
4. *hek’wa-šu-I îsa man-GEN-IV cheese ‘the man’s cheese’*
5. *hek’wa-šw-i anna man-GEN-V ear ‘the man’s ear’*
Other elements exhibiting gender agreement are demonstratives, possessives, personal and relative pronouns, adverbs, adpositions and even complementisers.

The number or proportion of languages making use of GG is difficult to estimate. Based on a sample of 256 languages, Corbett finds about half of them not to have a gender system (Corbett, 2013b). Gender is rarely found in indigenous languages of North America (especially those spoken in the West) and in Asian languages. Niger-Congo, Indo-European and the Nakh-Daghestanian family in the Caucasus are strongholds of gender, both in terms of speakers and languages. There is noticeable geographic clustering when it comes to the number of genders that a language differentiates: Two or three is most commonly encountered in Europe and the Americas; five-way systems are seldom found outside Africa and Papua New Guinea. It does not come as a surprise that the majority of languages, particularly those with a two- or three-way gender system, base their systems on sex, that is, natural gender. There is, however, a wide range concerning the amount of overlap between GG categories referred to as *masculine* or *feminine* and biologically male or female creatures: A 1:1 mapping is rarely found, whereas some languages at least designate all male humans (and, occasionally, deities), but nothing else by nouns in the *masculine* class. Non-sex-based systems are found most widely in the Niger-Congo area where five and more genders are not rare. These systems are all based on some type of animacy (Corbett, 2013c).

Both in sex-based and non-sex-based systems, semantics play an important role in assigning GG to a noun. No exclusively formal system – that is, a system that relies entirely on morphological or phonological cues to GG assignment – has ever been reported (although Afar, an East Cushitic language spoken in Ethiopia, comes close with just a small residue of words resisting formal assignment). It is conceivable that all systems started out as purely semantic systems with GG markers based on classifiers that, in turn, have been derived from content words (Corbett, 1991, sec. 10.2.1). In languages like Jakaltek (spoken in Guatemala), the classifier used alongside words denoting female humans is identical and etymologically traceable to the word *woman*, resulting in combinations like *ix ix* ‘woman woman’, meaning ‘the woman’ (Craig, 1986). Classifiers can give rise to both GG marking on independent elements and GG agreement: the former by their anaphoric use without a head noun, which makes them a possible source for demonstratives and determiners; the latter when classifiers are repeated in the noun phrase and eventually fuse with,
for instance, adjacent adjectives. Many of these lexical systems have been watered down through the centuries, so that their semantic basis ends up being difficult to trace. Among a sample of more than 100 languages, less than half rely exclusively on semantic cues for gender assignment (Corbett, 2013d), but even this number is probably an overestimate: There may be systems that have not been studied thoroughly enough to discover that formal properties also play a role.

The function of grammatical gender – a feature many languages can do without – has proven difficult to pinpoint. The most commonly mentioned advantage is improved reference tracking. Consider the German sentence in (6):

(6) Vorsichtig transportiert die Maschine das Glas in den Behälter, ohne dass er/sie/es dabei beschädigt wird.

‘The machine carefully transports the glass into the container without it-MAS/it-FEM/it-NEU being damaged.’

In the German sentence, it is immediately clear from the GG-marked pronouns in the subordinate clause whether it is the machine (feminine), the glass (neuter) or the container (masculine) that escapes damage. Of course, each of these meanings can also be expressed in languages like English – and not even clumsily, for instance ‘without being damaged’ when referring to the machine or ‘without the latter being damaged’ when referring to the container. Still, a GG system that is not dependent on the syntactic structure and does not carry obvious stylistic ramifications can be considered convenient. Additionally, pre-nominal gender-marked determiners and adjectives can facilitate processing by reducing the number of possible candidates for the upcoming noun slot (Köpcke & Zubin, 1984). Studies using ERPs or eye tracking have suggested that GG is indeed used this way (Friederici & Jacobsen, 1999; Lew-Williams & Fernald, 2007; van Berkum, Brown, Zwitserlood, Kooijman, & Hagoort, 2005).

It has also been shown that GG can be exploited for semantic purposes, such as conveying the speaker’s attitude: In some Polish dialects, for example, feminine forms are used to refer to women when they are married, whereas neuter forms typically designate women who are unmarried. In the Caucasian language Bats, nouns that refer to humans can be combined with marking of gender classes for non-humans to express scorn and disrespect. In Arabic baby talk, switching gender, that is, addressing a girl with masculine forms and vice versa, shows affection and liking (Corbett, 1991).
6.2 Grammatical gender in German

German, a West-Germanic language with 90 million native speakers (Ammon, 2014), has a tripartite GG system with classes traditionally called masculine, feminine and neuter. Its semantic basis is weak: Grammatically masculine or neuter nouns can denote female humans (der Gast ‘guest’; das Mädchen ‘girl’) and grammatically female nouns can refer to male humans (die Person ‘person’). There is, however, some evidence that gender assignment is governed by semantics in some lexical fields (Köpcke & Zubin, 1995). Morphological and phonological cues are the main source of GG predictability: Nominalised infinitives, for instance, are assigned neuter gender (gehen → das Gehen ‘walking’); the same is true when English gerunds are borrowed as loanwords (peeling → das Peeling ‘peeling’). Some suffixes are associated with a certain GG (Köpcke & Zubin, 2009): Words ending in -ling are masculine (der Däumling ≈ ‘Tom Thumb’; der Schwächling ‘wimp’), words ending in -heit or -ung are feminine (die Schönheit ‘beauty’; die Zeitung ‘newspaper’). Assignment based on phonology is less reliable, but still able to correctly predict the gender of a sizeable proportion of nouns: Monosyllabic nouns with /kn-/ as onset, for instance, are masculine (sole exception: das Knie ‘knee’); the coda clusters /-ft/, as in die Luft ‘air’, and /-xt/, as in die Nacht ‘night’, are strong predictors for feminine gender (Köpcke, 1982; Köpcke & Zubin, 1983).

In German, GG is unambiguously marked on definite singular determiners in the nominative. In the plural, in other cases and with indefinite determiners, the system is less straightforward. The Tables 18–20 give an exhaustive overview of GG marking in determiners and adjectives (examples taken from Dudenredaktion, 2009, pp. 488–491). There are three different patterns for adjective that are applied as follows: When combined with GG-marked definite determiners or demonstratives, adjectives follow the weak declension with few forms and a considerable degree of syncretism. The absence of determiners triggers the more differentiated strong declension. A so-called mixed declension is used when the adjective follows an indefinite determiner.

Even in the strong declension, the system is characterised by syncretisms, both gender-internally (nominative/accusative and dative/genitive in the feminine class are indistinguishable) and externally (kalter Milch, the dative or genitive of a feminine word, could also be the nominative of a masculine word). Apart from articles
Table 18: Weak declension with GG-marked definite determiners and only two adjective endings.

<table>
<thead>
<tr>
<th>Case</th>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Masculine</strong></td>
<td><strong>Feminine</strong></td>
<td><strong>Neuter</strong></td>
</tr>
<tr>
<td>Nominative</td>
<td>der kalte Rauch</td>
<td>die kalte Milch</td>
</tr>
<tr>
<td>Accusative</td>
<td>den kalte Rauch</td>
<td>die kalte Milch</td>
</tr>
<tr>
<td>Dative</td>
<td>den kalte Rauch</td>
<td>die kalte Milch</td>
</tr>
<tr>
<td>Genitive</td>
<td>den kalte Rauchs</td>
<td>die kalte Milchs</td>
</tr>
</tbody>
</table>

Table 19: Strong declension without a determiner, but with GG marking on the adjective.

<table>
<thead>
<tr>
<th>Case</th>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Masculine</strong></td>
<td><strong>Feminine</strong></td>
<td><strong>Neuter</strong></td>
</tr>
<tr>
<td>Nominative</td>
<td>kalter Rauch</td>
<td>kalte Milch</td>
</tr>
<tr>
<td>Accusative</td>
<td>kalten Rauch</td>
<td>kalte Milch</td>
</tr>
<tr>
<td>Dative</td>
<td>kalten Rauch</td>
<td>kalte Milch</td>
</tr>
<tr>
<td>Genitive</td>
<td>kalten Rauchs</td>
<td>kalte Milchs</td>
</tr>
</tbody>
</table>

Table 20: Mixed declension with indefinite determiner.

<table>
<thead>
<tr>
<th>Case</th>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Masculine</strong></td>
<td><strong>Feminine</strong></td>
<td><strong>Neuter</strong></td>
</tr>
<tr>
<td>Nominative</td>
<td>kein kalter Rauch</td>
<td>keine kalte Milch</td>
</tr>
<tr>
<td>Accusative</td>
<td>keinen kalten Rauch</td>
<td>keine kalte Milch</td>
</tr>
<tr>
<td>Dative</td>
<td>keinem kalten Rauch</td>
<td>keiner kalten Milch</td>
</tr>
<tr>
<td>Genitive</td>
<td>keines kalten Rauchs</td>
<td>keiner kalten Milchs</td>
</tr>
</tbody>
</table>
and adjectives, gender is marked in German on many types of pronouns (relative, possessive, interrogative).

Different approaches can be followed to determine whether there is a default GG in German. Statistically, the masculine class seems to be largest. Calculations of the actual share of monomorphemic nouns belonging to this class, however, have produced widely varying results, ranging from 66% (Köpcke & Zubin, 2009) to 38% (Schiller & Caramazza, 2003). The latter count is based on the CELEX corpus and takes frequency of occurrence into account (feminine: 35.4%, neuter: 25.8%). When trying to determine the default gender on the basis of morphological productivity, the feminine class would come in first. Rather than as a default, neuter could be seen as the ‘last resort’ GG that is selected when all phonological, morphological and semantic assignment principles have failed. In L1 and L2 acquisition, the definite article for singular feminine nouns and plural nouns of all genders, *die*, is sometimes overused and has been considered as a learner default (Bewer, 2004; Mills, 1986; Wegener, 1999). In German monolinguals, GG is acquired early, compared to other languages (e.g., Dutch: de Houwer & Gillis, 1998; van der Velde, 2004). German-speaking children are typically able to produce target-like marking on the majority of determiner-noun combinations between the ages of three and four (Bewer, 2004; Corbett, 1991). GG agreement on the adjective is acquired slightly later than the selection of the appropriate determiner.
L2 immersion engenders little change in bilingual natives
This section was published as

Abstract
Bilingual and monolingual language processing differ, presumably because of constant parallel activation of both languages in bilinguals. We attempt to isolate the effects of parallel activation in a group of German first-language (L1) attriters, who have grown up as monolingual natives before emigrating to an L2 environment. We hypothesised that prolonged immersion will lead to changes in the processing of morphosyntactic violations. Two types of constructions were presented as stimuli in an event-related potential experiment: (1) verb form combinations (auxiliaries + past participles and modals + infinitives) and (2) determiner–noun combinations marked for grammatical gender. L1 attriters showed the same response to violations of gender agreement as monolingual controls (i.e., a significant P600 effect strongest over posterior electrodes). Incorrect verb form combinations also elicited a significant posterior P600 effect in both groups. In attriters, however, there was an additional posterior N400 effect for this type of violation. Such biphasic patterns have been found before in L1 and L2 speakers of English and might reflect the influence of this language. Generally, we interpret our results as evidence for the stability of the deeply entrenched L1 system, even in the face of L2 interference.

Acknowledgements
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6.3.1 Introduction

Bilinguals do not process language the way monolinguals do (Grosjean, 1982, 1998), presumably because of constant parallel activation of both languages (Kroll et al., 2006; Kroll & Tokowicz, 2005). However, it is difficult to interpret the group differences: Apart from the number of languages they speak, monolinguals and bilinguals usually differ on factors such as the amount of linguistic input, age of acquisition, proficiency etc. It is unclear which processing differences can be attributed to incomplete L2 acquisition and which to the presence of another language. To overcome these problems, we present a comparison of German first-language (L1) attriters and monolinguals. Having grown up in a monolingual setting, attriters had full native L1 input and proficiency before emigration. As adults, they have emigrated to an environment where their L1 is not used and they are immersed in a second language (L2; here: English). Using L1 stimuli, we should be able to measure pure effects of bilingual language competition on processing in these speakers. We report the results of an event-related potential (ERP) experiment on two morphosyntactic phenomena: non-finite verb forms and grammatical gender (GG).

In languages marking GG, nouns are assigned to classes; elements grammatically related to these nouns have to be inflected according to class membership (Corbett, 1991). Violations in GG agreement consistently elicit late positive effects in monolingual L1 speakers (German: Gunter, Friederici, & Schriefers, 2000; Dutch: Hagoort & Brown, 1999; French: Frenck-Mestre, Foucart, Carrasco, & Herschensohn, 2009).

Although the same effects as in monolinguals are sometimes found in late L2 learners (L1 German/L2 French: Frenck-Mestre et al., 2009; L1 German/L2 Dutch: Sabourin & Stowe, 2008), sometimes they are not (L1 Romance/L2 Dutch: Meulman, Stowe, Sprenger, Bresser, & Schmid, 2014; Sabourin & Stowe, 2008; L1 English/L2 French: Foucart & Frenck-Mestre, 2012). These results may depend either on factors such as L1–L2 similarity, age of acquisition and proficiency or on the fact that the learners are bilinguals. The processing of verb form combinations (auxiliaries + past participles and modals + infinitives), on the other hand, does not differ as much. Incorrect combinations reliably elicit late positive effects in both monolinguals (Dutch: Gunter, Stowe, & Mulder, 1997) and late L2 learners (L1 German and L1 Romance/L2 Dutch: Meulman et al., 2014; Sabourin & Stowe, 2008).

We present the first comparison of ERP data from L1 attriters and monolinguals. The two phenomena that we have selected differ between German and English in
specific ways: GG is marked in German, but not in English, thus, no direct competition is expected. However, GG is an unpredictable lexical property of nouns. Many studies have shown that L2 immersion can affect accessibility of the L1 lexicon (Schmid & Köpke, 2009); thus, GG processing might change for that reason. Verb form combinations are rule- rather than item-based and syntactically similar in German and English. The morphological makeup of the non-finite forms differs, though, involving a circumfix structure for past participles in German.

We hypothesise that L1 attriters and monolinguals will not differ in the processing of non-finite verb forms, irrespective of the morphological differences. For gender processing, by contrast, we hypothesise that violations may differ, reflecting the impact of the L2 on access to the mental lexicon of the bilinguals.

6.3.2 Materials and methods
6.3.2.1 Participants
Fifty-eight native speakers of German participated; five were excluded due to excessive artefacts in the electroencephalographic (EEG) signal. Of the remaining 53 participants, 27 were residents of Germany (= control group speakers) and 26 were residents of the USA or Anglophone Canada (= attriters). All participants were right-handed and reported no neurological, speech or hearing disorders. Written consent was obtained from all participants using forms that were approved by local ethics committees. Participants were debriefed at the end of the study and received a small fee for participation.

Participant characteristics can be found in Table 21. Gender was not controlled across groups. L1 use is an average of self reports on three settings (home, work, elsewhere). Proficiency was assessed using a cloze test, constructed by Schmid (2011), in which participants filled in two texts with a respective share of 37% or 41% incomplete words. Gender assignment was tested by having participants assign the correct gender-marked article to nouns; to remove the effects of guessing, each of the 138 items was repeated three times (in randomised order).

6.3.2.2 Materials
On the basis of a Dutch ERP experiment (Loerts, 2012), 144 German sentences in two structures were created (for examples, see Figure 9): (1) Verb agreement (48 sentences): Auxiliaries were combined with past participles and modals with infinitives.
Table 21: Participant characteristics.

<table>
<thead>
<tr>
<th>Control group</th>
<th>Attriter group</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td>33.0 %</td>
<td>8.0 %</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>40.2 (σ: 11.1; 22–65)</td>
<td>44.4 (σ: 9.0, 29–64)</td>
</tr>
<tr>
<td><strong>Age of emigration</strong></td>
<td>–</td>
<td>27.6 (σ: 4.5; 21–39)</td>
</tr>
<tr>
<td><strong>Length of residence in L2 setting</strong></td>
<td>–</td>
<td>17.2 (σ: 8.1; 6.5–34)</td>
</tr>
<tr>
<td><strong>L1 use</strong></td>
<td>97.8 % (σ: 3.9; 86.7–100)</td>
<td>19.4 % (σ: 18.4; 0–76.7)</td>
</tr>
<tr>
<td><strong>Proficiency test</strong></td>
<td>93.2 % (σ: 2.7; 86–97.7)</td>
<td>88.6 % (σ: 6.9; 72.1–97.7)</td>
</tr>
<tr>
<td><strong>Gender assignment</strong></td>
<td>99.9 % (σ: 0.3; 99–100)</td>
<td>99.9 % (σ: 0.3; 99–100)</td>
</tr>
</tbody>
</table>

a: Correct responses. Spelling errors were not counted as incorrect responses.

b: Correct responses. Nouns that were assigned the correct article 2 out of 3 times were counted as correct.

Only verbs with a regular inflection were included. For the ungrammatical counterparts, combinations were swapped, pairing auxiliaries with infinitives and modals with past participles. (2) Gender agreement of determiners with nouns (96 sentences): Masculine and neuter nouns were combined with determiners that agreed in GG. Determiners and nouns were adjacent in half of the sentences (A), whereas an adjective intervened in the other half (B). Some speakers might process the highly frequent determiner-noun combinations in the adjacent condition (A) as pre-learned chunks without actually computing gender agreement (cf. Ullman, 2004). We have therefore included the non-adjacent condition (B), resulting in less frequent determiner-adjective-noun combinations, in which a chunk-based processing strategy is less likely. For ungrammatical sentences, combinations were swapped, pairing masculine determiners with neuter nouns and vice versa. Only highly frequent nouns and verbs were used (nouns: x̄ = 1.62 (0.4–2.7); verbs: x̄ = 1.78 (0.3–2.9) on log lemma frequency per million words in the DeReKo corpus; Kupietz, Belica, Keibel, & Witt, 2010). The experimental sentences (50% incorrect in each condition) were interspersed with 134 correct filler sentences, which increased the proportion of correct sentences to 74.1%. Feminine gender was avoided because the determiner associated with this gender is identical to the plural determiner that is used for all three genders (die).
The sentences were recorded by a female native speaker of German with a standard accent. The region surrounding the target words was cross-spliced from correct to incorrect sentences and vice versa to avoid potential confounds in the form of prosodic cues. Sentences were presented in four different lists with no repetition of items.

6.3.2.3 Procedure
The EEG experiment was part of a research project in which participants were tested in two two-hour sessions. The pen-and-paper cloze test was completed during the first session.

ERPs were recorded during the second session. The recording situation was kept the same across all four testing locations. Participants were tested individually in sound-attenuated chambers. Sentence recordings were presented through loudspeakers using E-Prime (Schneider, Eschman, & Zuccolotto, 2002a, 2002b). After each sentence, participants had to make a binary acceptability judgment. Participants were asked to avoid eye and body movements as well as blinking during sentence presentation. The experiment was divided into four blocks with pauses in between. It lasted about one hour. After the recording, participants completed the pen-and-paper gender assignment task.

6.3.2.4 EEG recording and analysis
Participants were tested at labs in four cities: Toronto (TO; n = 12), New York (NY, n = 14), Mainz (MZ; n = 22) and Hamburg (HH; n = 5). (We carried out additional analyses including the factor location. These showed that all effects of interest, reported below, were not influenced by differences in the EEG recording set-up at the different labs.) EEGs were recorded at 500 Hz/22 bit (except for TO: 512 Hz, resampled to 500 Hz) from 56 Ag/Ag Cl electrodes in different types of caps (MZ/HH: Easy Cap [Easy Cap GmbH, Wörthsee-Etterschlag, Germany]; NY: Neuroscan Quik-Cap [Compumedics, Charlotte, NC, USA]; TO: BioSemi [BioSemi B.V., Amsterdam, The Netherlands]). Eye movements were monitored through additional electrodes, placed at the outer canthi as well as above and below the eyes. Scalp signals were measured against reference electrodes placed at the left mastoid (MZ/TO) or on the nose tip (HH/NY). Impedances were reduced to below 15 kΩ. BrainAmp (MZ/HH), SynAmp 2 (NY) and BioSemi (TO) amplifiers were used.
The data were re-referenced to averaged mastoids and filtered with a band-pass filter of 0.1–40 Hz. The data were segmented and time-locked to the onset of the target word (500 ms before to 1400 ms after stimulus onset). Irrespective of behavioural responses, trials without muscular or ocular artefacts were included in averaged ERPs. Ocular artefacts were corrected. Due to individual channel artefacts, 2.2% of the data had to be rejected in the attriter group and 0.4% in the control group. The data were normalised in a 200 ms baseline period before the onset of the target words. Electrodes were grouped into eight regions of interest (ROIs) with five electrodes each (see Figure 9).

The amplitudes of the ERP waveforms were analysed in two time windows: 300–500 ms (typical for LAN/N400 effects) and 600–1200 ms (typical for P600 effects). Grand mean analyses of variance (ANOVAs) were calculated separately for each time window and structure. They included the factors group (controls/attriters) and correctness (correct/incorrect). In lateral regions (LA/LC/LP and RA/RC/RP), hemisphere (left/right) and anteriority (frontal/central/posterior) were also included; in medial regions (MC/MP), only anteriority (central/posterior) was included. For violations of the sphericity assumption, the Greenhouse-Geisser correction was applied. Only main effects of or interactions with correctness are reported. Significant higher-level interactions are interpreted rather than main effects or lower-level interactions. False discovery rate correction was applied in follow-up tests to avoid Type 1 errors.

6.3.3 Results
6.3.3.1 Behavioural results
The performance on the acceptability judgement task was at ceiling for both groups (controls: \( \bar{x} = 98.4\% \), attriters: \( \bar{x} = 97.4\% \)). An ANOVA, conducted on the arcsine transformed proportions of correct responses, showed a marginally significant main effect of Group \( F(1,51) = 3.37, p = .072 \), reflecting the slightly lower accuracy of the L1 attriters. The Correctness × Structure interaction was significant \( F(2,102) = 8.40, p = .001 \).
In the verb condition, paired comparisons show a marginally better performance on ungrammatical sentences \( t(99.2) = -1.7478, p = .084; \) corr.: \( \bar{x} = 97.7\% \), incorr.: \( \bar{x} = 98.7\% \).
In the gender conditions, we find a significantly better performance on grammatical sentences for the adjacent structure (2A) \( t(101.2) = 2.9577, p = .004 \); corr.: \( \bar{x} = 98.3\% \),


**Figure 9**: ERP waveforms of all conditions for both participant groups, taken from the mid-posterior ROI. Waveforms of all ROIs are available in the appendix (see section 10.6–10.8).

incorr.: $\bar{x} = 96.4\%$] and no significant differences for the non-adjacent structure (2B) [$t(103.4) = 1.541, p = .1264$; mean corr.: $\bar{x} = 98.4\%$, incorr.: $\bar{x} = 97.7\%$].

6.3.3.2 ERP results: Grand mean analyses

Figure 9 shows the grand mean ERP waveforms for controls and attriters, respectively. Detailed results of the omnibus ANOVAs are available in the appendix (see section 10.5). Factors are Group (G), Correctness (C), Anteriority (A) and Hemisphere (H).

**Verb form combinations.** In the 300–500 ms window, we found more negative voltages (i.e., an N400 effect) in attriters for the ungrammatical sentences. This was statistically supported by a significant $G \times C \times A$ interaction for lateral electrodes. Follow-up analyses showed no significant main effects or interactions in controls. In attriters, by contrast, the $C \times A$ interaction was marginally significant [$F(2,50) = 4.85, p = .054$] with post-hoc tests showing a posterior effect [frontal/central: both $Fs < 1$; posterior:
For midline electrodes, there was a significant G×C×A interaction. In controls, follow-up analyses yielded no significant main effects or interactions. In attriters, there was a significant C×A interaction \([F(1,25)=8.80, p=.014]\), again reflecting a posterior effect [central: \(F<1\); posterior: \(F(1,25)=8.95, p=.012\)].

In the 600–1200 ms window, both groups showed more positive voltages (i.e., a P600 effect) for the ungrammatical sentences. This was supported by a significant G×C×A×H interaction for lateral electrodes. Follow-up analyses revealed a significant C×A interaction in the attriters \([F(2,50)=33.97, p<.001]\), reflecting an effect with a posterior distribution [frontal: \(F<1\); central: \(F(1,25)=2.96, p=.146\); posterior: \(F(1,25)=26.14, p<.001\)]. In controls, there was a significant C×A×H interaction. On frontal electrodes, there was neither a significant effect of C \([F(1,26)=1.66, p=.209]\) nor a significant C×H interaction \([F(1,26)=2.50, p=.126]\). On central electrodes, there was a significant C×H interaction \([F(1,26)=17.04, p=.023]\), but effects of C were evident in neither hemisphere \([both Fs<1.44]\). On posterior electrodes, there was also a significant C×A interaction with significant effects of C in both regions [central: \(F(1,52)=29.15, p<.001\); posterior: \(F(1,52)=85.05, p<.001\)].

To sum up, we see a biphasic N400–P600 pattern over posterior sites in the attriters; visual inspection showed that this was present in the majority of the speakers in this group. The control group speakers showed no effect in the N400 time window, but a P600 effect over central and posterior electrodes.

**Gender agreement: adjacent condition.** There were no significant main effects or interactions in the 300–500 ms window.

In the 600–1200 ms window, we see more positive voltages (i.e., a P600 effect) for ungrammatical sentences in both groups. This was confirmed by a significant C×A×H interaction for lateral electrodes. Follow-up analyses showed a significant C×H interaction on frontal electrodes \([F(1,52)=5.49, p=.023]\), but effects of C were evident in neither hemisphere \([both Fs<1.44]\). On central electrodes, there was also a significant C×H interaction \([F(1,52)=19.18, p<.001]\), reflecting a dextral effect of C [left: \(F(1,52)=2.33, p=.133\); right: \(F(1,52)=24.43, p<.001\)]. On posterior electrodes, the C×H interaction was significant as well \([F(1,52)=8.54, p=.008]\) with effects of C in both hemispheres [left: \(F(1,52)=59.79, p<.001\); right: \(F(1,52)=110.44, p<.001\)]. For midline electrodes, the C×A interaction was significant, reflecting an effect of C in both regions [central: \(F(1,52)=20.40, p<.001\); posterior: \(F(1,52)=93.09, p<.001\)].
In summary, we observed no effects in the N400 time window, but a strong P600 effect over posterior and central electrodes in both groups.

**Gender agreement: non-adjacent condition.** Again, no significant main effects or interactions were found in the 300–500 ms window.

In the 600–1200 ms window, ungrammatical sentences elicited more positive voltages (i.e., a P600 effect) in both groups. This was statistically supported by significant C × A × H interaction for lateral electrodes. Follow-up analyses revealed a significant C × H interaction on frontal electrodes \( F(1,52) = 7.08, p = .015 \). However, effects of C were present in neither hemisphere [left: \( F < 1 \); right: \( F(1,52) = 2.38, p = .258 \)]. A significant C × H interaction was also found for central electrodes \( F(1,52) = 18.96, p < .001 \] with effects of C in both hemispheres [left: \( F(1,52) = 11.52, p = .001 \]; right: \( F(1,52) = 25.76, p < .001 \]. For posterior electrodes, there was only a significant effect of C \( F(1,52) = 69.15, p < .001 \]. For midline electrodes, we found a significant C × A interaction with follow-up analyses showing effects of C in both regions [central: \( F(1,52) = 31.84, p < .001 \]; posterior: \( F(1,52) = 88.18, p < .001 \].

As in the adjacent condition, no effects in the N400 time window were found, but there was a strong P600 effect over central and posterior electrodes for both groups.

### 6.3.4 Discussion

To isolate the effects of bilingualism on language processing, we compared monolingual speakers of German to L1 attriters of German with L2 English. We analysed ERP data in three structures: (1) agreement in non-finite verb forms; (2) GG agreement between adjacent (A) and non-adjacent (B) determiners and nouns. In previous studies, violations as in (1) were processed the same across monolingual L1 and bilingual L2, whereas (2A) and (2B) displayed some variability in late bilinguals. We hypothesised that attriters would be able to process verb agreement in a native-like way, but that their processing of GG agreement might have changed because of L2 influence on their access to the mental lexicon.

In monolingual controls, violations in all three conditions elicited late positive effects over posterior electrodes (i.e., a P600). These findings are in line with previous research (Foucart & Frenck-Mestre, 2010; Gunter et al., 2000, 1997; Hagoort & Brown, 1999). In this time window, bilingual attriters showed fully native-like ERP signatures for violations of verb agreement. This established that, as expected, attriters’ capability to process regular L1 morphosyntax remained unaltered. Contrary to
our hypothesis, attriters were also indistinguishable from controls in the two GG conditions with no effect of the distance between the agreeing elements. This is a surprising and interesting result because it shows that routines used for processing L1 structures at the interface of the lexicon and morphosyntax remain robust even after prolonged L2 immersion. It suggests that (passive) language processing, as tested in the EEG, is less susceptible to attrition effects than (active) language production, for which the written proficiency test shows a group difference with a slightly lower score in the attriters.

Controls and attriters did, however, differ in the verb condition. For attriters only, violations led to an additional early negative effect over posterior electrodes (i.e., an N400). Biphasic N400–P600 patterns for such constructions have been found before in monolingual natives of Dutch, which is morphologically similar to German, and for English (Kutas & Hillyard, 1983; Loerts, 2012; Meulman et al., 2014; Sabourin & Stowe, 2008). Dutch natives, unlike Germans, are frequently exposed to and proficient in English. The fact that we observed the biphasic pattern in the L1 attriters, who are immersed in an Anglophone setting, is suggestive of a role of language contact with English in the generation of this additional N400 effect. The fact that attriters process an L1 structure in a way that is similar to the monolingual processing of their L2 (English) is reminiscent of the use of L1 strategies in L2 processing by learners (Frenck-Mestre, 2005). It cannot be excluded, however, that the group differences are related to the reduced L1 use and proficiency in the attriters, rather than to the transfer of L2 processing strategies.

6.3.5 Conclusion

We have investigated the impact of bilingualism on morphosyntactic processing. On comparing monolingual controls and bilingual L1 attriters, we found that both groups show late positive effects in response to verb agreement and GG agreement violations. The latter is surprising, given the lexical nature of GG and the vulnerability of the lexicon in L1 attrition. We interpret these results as evidence for the stability of the deeply entrenched L1 system, even in the face of L2 interference.