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FIRST LANGUAGE ATTRITION: WHAT IT IS, WHAT IT ISN'T, AND WHAT IT CAN BE

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FIRST LANGUAGE ATTRITION: WHAT IT IS, WHAT IT ISN'T, AND WHAT IT CAN BE[f]

This review aims at clarifying the concept of first language attrition by tracing its limits, identifying its phenomenological and contextual constraints, discussing controversies associated with its definition, and suggesting potential future directions. We start by reviewing different definitions of attrition as well as associated inconsistencies. We then discuss the underlying mechanisms of first language attrition and review available evidence supporting different background hypotheses. Finally, we attempt to provide the groundwork to build a unified theoretical framework allowing for generalizable results. To this end, we suggest the deployment of a rigorous neuroscientific approach, in search of neural markers of first language attrition in different linguistic domains, putting forward hypothetical experimental ways to identify attrition's neural traces and formulating predictions for each of the proposed experimental paradigms.

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Keywords: first language attrition; bilingualism; cross-linguistic interactions; EEG/MEG; fMRI

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1. Introduction

We live in an increasingly globalized world whose one inalienable feature is continuously growing international migration. UN DESA data suggest that international migration continues to grow year-on-year: it doubled in recent 20 years to reach 260 million in 2017 (United Nations, 2018). In USA alone, international migrant population approaches 50 million people. An inevitable product of mass migration is bi- and multilingualism – it is estimated that more than half of the world's population now speak two or more languages (Ansaldo, et al., 2008).

One of the key features of bi- and multilingualism is the necessity for the speakers to simultaneously store and use two or more distinct languages. Existing literature provides ample evidence that this leads to a constant interplay between the first and the second language (L1, L2) at the levels of phonology (Goldrick et al. 2014), lexicon (Malt et al. 2015), and grammar (Hartsuiker et al. 2004). Most importantly for the purposes of this paper, interactions between L1 and L2 are reciprocal: not only do specific features of L1 affect the use of L2, but also performance in the native language changes under the influence of L2. An important and relatively under-studied aspect associated with the latter is known as *native language attrition* – the gradual decrease of native language performance that takes place alongside with, and even without increase in L2 proficiency. Notwithstanding the research efforts, terminological definitions - alongside results and findings - vary considerably across studies, leading to a rather diffused understanding of what the nature of the phenomenon of attrition would be. Importantly, despite the long-standing interest in this topic, it remains largely under-studied, especially at the level of the neurocognitive mechanisms underlying linguistic phenomena and processes.
This paper is an attempt at clarifying the concept of attrition by tracing its limits, identifying its phenomenological and contextual constraints, and summarizing what attrition *may mean* in principle, making our way through the "terminological jungle" of contact linguistics (Köpke, 2004a). We will discuss the underlying mechanisms of L1 attrition and review the evidence supporting different background hypotheses. The last section will provide the groundwork aiming at building a unified theoretical framework allowing for generalizable results, by means of suggesting the deployment of a rigorous neuroscientific approach, in search of *neural markers* of L1 attrition in different linguistic domains.

1.1. Defining language attrition: what it is, and what it is not

The first thing one may notice when addressing a relatively young and underexplored field like language attrition is an almost equal ratio between experimental studies and theoretical contributions. The amount of available theoretical literature testifies to the extensive effort made to define such an equivocal phenomenon as attrition. Various consequences of language contact have drawn increasing attention during the past 40 years, prompting investigations from different perspectives (e.g. linguistics, philosophy, neuroimaging). This heterogeneity has led to the development of what some authors have called a "terminological jungle" (Köpke, 2004a), with inconsistencies in the existing terminology both between and within different traditions. In this first section, we provide a brief overview of the terminological inventory used in L1 attrition research with a specific focus on the origin, conceptual definitions, and operationalization of the existing terms. We then try to tackle the definition problem by providing a series of distinctions between similar yet different phenomena resulting from language contact, moving from more general to more specific notions.

One important distinction that needs to be made from the outset is that between the terms *language change* and *language shift*. *Language change* refers to changes in the structure of a given language (*i. e.* the linguistic form), that may occur intra-generationally (within individuals over time) or inter-generationally (across individuals over time) (Gardner-Chloros, 2001; Yagmur, 2004) while *language shift* indicates variations in the functional aspects of language use (*i.e.* an overall reduction in language spread), happening at the societal (as opposed to the individual) level (Dorian, 1982; Gardner-Chloros, 2001; Milroy, 2001). Narrowing the scope of the latter term to the phenomenon of language decay, we need to distinguish between *loss*, *shift*, and *attrition*. One commonly adopted distinction (e.g. Schmid, 2002; Köpke, 2004b; De Bot's, 2001; De Leeuw, 2008; Zaretsky and Bar-Shalom, 2010) relies upon the notion of *loss* as a generic term incorporating both shift and attrition. Language *shift*, therefore, would refer to intergenerational loss (e.g. reduced native language use in second generation migrants, also known as "heritage speakers"), whereas language *attrition* – to an intragenerational loss (e.g. reduction in native language proficiency in emigrated individuals). In other words, attrition indicates changes occurring at the cognitive/psycholinguistic level, while language shift implies a more sociolinguistic phenomenon.

One helpful way to define language attrition is to initially determine what attrition *is not* and then synthesize different attempts to define what attrition *is* or *may be*. Köpke (2004a) came up with a series of characteristics that help to shape a definition of the phenomenon. Most generally, attrition must be not only intragenerational and individual, but also *non-pathological* (that is, not due to a neurological, psychiatric or other deficit, such as dementia or post-injury aphasia). Second, it must affect not only the amount or frequency of language use, but the *linguistic performance* as such; that is, an infrequent use of the language is not per se the sign of attrition, as long as the performance in the (rare) use remains intact. Capitalizing on these points, Köpke and Schmid (2004) worked out what is probably, up to the present day, the most commonly accepted definition of language attrition: "the non-pathological decrease in a language that had previously been acquired by an individual". Attrition would hence reflect a situation whereby a speaker is losing proficiency in a language she previously mastered, not due to any brain degeneration or an age-related cognitive impairment but as a result of "a change in linguistic behavior due to a severance of the contact with the community in which the language is spoken" (Schmid, 2008).

While these general definitional constraints are very helpful, this degree of approximation makes the feat of pinning down the phenomenon of attrition anything but accomplished. To gain a better insight, we find it useful to briefly point out the major factors underlying attrition. Existing literature points to the three main factors predicting the severity and the degree of the L1 attrition. The first factor is the age of onset: individuals that abandon their native language environment before puberty seem likely to experience a more severe attrition (e.g. Karayayla and Schimd, 2019). This may be related to the maturational constraints imposed by puberty on language acquisition: in line with the Critical Period Hypothesis (CPH, Lenneberg, 1967), there is an optimal time window during individual development for acquiring L1 or L2, after which the attainment of nativelike proficiency becomes difficult or even impossible. When applied to native language attrition, CPH states that a deep erosion of the L1 system would only be possible with onsets before the end of the critical period (usually argued to coincide with or precede puberty), although this point is still under debate (for a review, see Bylund, 2009; Schmid and Köpke, 2017). Thus, pre-adolescent origin of L1 decay/erosion may be considered a result of an incomplete L1 acquisition rather than attrition *per se* in its strict definition (e.g. Bolonyai, 2007). Here, we will mainly focus on late (i.e. postpubescent) attriters in an attempt to avoid any unpredictable variability resulting from prepubescent onset of language erosion (for a review, see Schmid and Köpke, 2017). Second, the amount of exposure to the native language is also implicated as an influencing factor, with higher levels of language use generally associated with a better language retention (e.g. Schmid and Yilmaz, 2018; Karayayla and Schimd, 2019; for a review, see Schmid and Köpke, 2017; see also section 2.2). Third, the individual's attitude towards their native language also appears to affect the development of attrition. A remarkable example is a study investigating attrition in German Jewish refugees who fled to anglophone countries before World War II: the degree of negative attitude towards German, the "oppressor's language", was found to have influenced the severity of attrition much more than the two other factors (Schimd, 2002).

2. The origin of attrition: cross-linguistic influence, language-internal reorganization, or lack of exposure?

A key question regarding attrition relates to its causal mechanism(s). Most importantly, this question concerns the neurobiological basis of attrition, an area that remains underexplored until the present day. The neurobiological bases of attrition are of utmost importance as their understanding is necessary to be able to answer the most fundamental question regarding the phenomenon: is attrition a phenomenon caused by progressive disuse of the native language and the associated reshaping of the corresponding neurolinguistic circuits? In other words, would it be possible to observe attrition even without any contact with L2? Or is attrition a “collateral damage” of the L2 acquisition, originating from cross-linguistic influence? In the next section, we review existing evidence in favor of both views.

2.1. L2 effects versus L1 reorganization

Existing literature offers numerous attempts at assessing the role of L2 in L1 attrition; these studies, however, report mixed results. Several studies have demonstrated that various aspects of L2 knowledge and use may determine the depth of L1 attrition. These L2 effects have been reported in different linguistic domains, *e.g.* phonology (*e.g.* de Leeuw,et al., 2018), morphology (*e.g.* Dussias, 2004), syntax (*e.g.* Chamorro et al., 2016a), lexicon (*e.g.* Schimd and Jarvis, 2014) and semantics (*e.g.* Ben Rafael, 2001), across different L1-L2 combinations, both in linguistically/typologically close pairs (*e.g.* German–Dutch; Ribbert and Kuiken, 2009) and in distant ones (*e.g.* Korean–French; Ventureyra et al., 2004). Overall, the process of attrition is usually attributed by the authors to cross-linguistic influence exerted by the L2 on the native language system (*e.g.* Ben Hutz, 2004; Rafael, 2001). Nonetheless, explanations offered by many such studies are not necessarily unequivocal. For example, a vast majority of attrition studies used English as the L2. English is an *analytical* language, relying more on a limited inventory of syntactic choices than on lexical morphology and word order to render the underlying conceptual message. Given these features, when English is the L2 in the studied sample, it is often hard to conclusively disentangle the cross-linguistic interference factors in attrition from *L1-internal* factors, such as simplification or generalization. Simplification and generalization consist of a shift towards a simpler common linguistic rule that is functional to both L1 and L2 (even if less typical of one’s L1). This process could be driven by cost-efficiency purposes: to relieve the cognitive burden on the linguistic system, an attriter would shift to a less costly, simpler rule common for both languages. This rule often happens to belong to the system of English, and the process could therefore be misinterpreted as a more general phenomenon of L2-to-L1 transfer (Schmid, 2002; Köpke and Schmid, 2004).

This suggestion received some support from studies comparing groups of attriters with the same L1 but different L2s. Schoenmakers-Klein Gunnewiek (1998), for example, investigated semantic L2 interference in Portuguese/Dutch and Portuguese/French attriters. The findings indicated very little L2 interference, lacking conclusive evidence for an effect of L2 influence on semantics in the attrition process. Similarly, Köpke's (1999) study could not present a strong case for L2 effects on morpho-syntactic attrition in German/English and German/French bilinguals , as L2 influence did not appear to be the only source of L1 attrition (differently from the author's original hypothesis). A lack of conclusive evidence also emerged in a paper by Isurin (2005), which reported two studies: a longitudinal case study and a cross-sectional study, investigating L2 influence on word-order preferences in Russian/English attriters. Both studies used a story retelling task in Russian and reported a shift from the use of the VSO word order – relatively frequent in L1 Russian story retelling – towards SVO, the word order frequent in both languages but less frequent specifically in story retelling in Russian. While this result appears to support the L2 interference hypothesis, in that the strong preference for SVO in English affected the frequency of use of alternative word orders in Russian, this interpretation is far from conclusive. The problem is that the SVO is not only acceptable in Russian story retelling, it is also the most frequent word order in Russian overall. As a result, the observed shift may reflect L1-internal generalization processes rather than transfer from L2, with participants shifting to the word order shared by both language and very frequent in both L1 and L2. The present example is well representative of how hazy can the picture appear in current attrition research: this same result might in fact support either one of the two contrasting hypotheses, depending on which underlying mechanism it is ascribed to.

Adding to an already mixed picture, Altenberg (1991) reported a study using a grammaticality judgment task, in which sentences that were ungrammatical in L1 but marginal in L2 were perceived as more acceptable than sentences completely ungrammatical in both languages, a result that seems to support the L2-to-L1 cross-linguistic influence hypothesis. Nonetheless, this result needs to be considered with extreme caution, as it used a very small sample size of only two participants. Finally, Pelc (2001) reported similar results in favor of L2-to-L1 transfer as the cause of L1 attrition, in a much larger sample of Greek/English attriters. The results showed an influence of L2 grammaticality on the acceptability judgments of L1 ungrammatical sentences. On the other hand, an investigation on Russian/English attriters by Laleko (2007) reported results in favor of the role of L1-internal factors in driving the attrition process. When borrowing English words during Russian speech, attriters were reported to develop a simplified rule for assigning gender, as compared to the standard rule in Russian. Yet, such new gender-assignment strategy followed a simplified phonological rule derived from Russian, and not from English: words ending in a consonant were deemed as masculine. Since the attrition process developed along the lines of a L1-internal rule, the author interpreted the results as supporting the role of language-internal processes, rather than L2 transfer, in causing L1 attrition.

Overall, mixed evidence emerges in the literature on the causes of L1 attrition. While some results point towards L2-to-L1 cross-linguistic influence as the cause of L1 attrition, others highlight the role played by L1-internal processes of reorganization, suggesting that the phenomenon would originate within the boundaries of the L1 linguistic system. In the next section, we deepen the discussion on the role played by L1-related factors in the attrition process, exploring the possibility that L1 attrition might stem from a reduced exposure to L1, with a focus on the potential effects of quality, beside quantity, of such exposure.

2.2. Exposure to L1: Quantity and quality

Many studies discussed in the previous section attribute attrition to the influence of the L2. It is, however, equally possible that attrition could result from a reduced exposure to and/or use of, L1. Studies have addressed this possibility by investigating the effect of the amount of L1 contact on the attrition process. As with L2 effects, the corresponding evidence is quite inconsistent. On the one hand, several studies have reported higher levels of attrition in participants who had a progressively weaker contact with their L1 (de Bot et al., 1991; Köpke, 1999, Isurin, 2007; Opitz, 2013; Chamorro et al., 2016b; Bergman et al., 2016; Kasparian et al., 2017; Schmid and Yilmaz, 2018; Karayayla and Schmid, 2019) supporting the idea that the amount of L1 contact predicts the severity of attrition. Note that these studies are quite heterogeneous in their use of experimental methodologies including EEG (Kasparian et al., 2017), eye-tracking (Chamorro et al., 2016b), and behavioral methods. Moreover, these findings are corroborated by the research investigating attrition in adopted children who show fast, almost absolute, and irreversible attrition of their native language due to the total severance from L1 use (Isurin, 2000; Nicoladis and Grabois, 2002; Pallier et al., 2003; Ventureyra et al., 2004). In contrast to this, other studies have failed to find a reliable correlation between the amount of L1 exposure and the severity of L1 attrition (Jaspaert and Kroon, 1989; Altenberg, 1991; Grosjean and Py, 1991; Olshtain and Barzilay, 1991; Major, 1992; Ben Rafael, 2001; Jarvis, 2003; Schmid and Jarvis, 2014). Different explanations have been provided to account for this inconsistency.

One plausible explanation lies with the intrinsic difficulty in measuring the amount of L1 exposure: L1 exposure assessment relies largely on self-reports, which may in turn be influenced by factors such as an individual's attitudes towards their native language and the interviewer, biasing their self-assessment responses.

Another issue related to the impact of L1 use over native language attrition is the importance of taking into account not only *quantity*, but also *quality* of L1 exposure. Indeed, several studies have shown a dissociation between the susceptibility of attrition to exposure in formal (*i.e.* professional) and in informal (*i.e.* family or friends) contexts: speakers who maintain higher levels of L1 usage in formal contexts have shown lower levels of attrition while stronger attrition has been found in the individuals who use L1 mainly with their friends and family (Schmid, 2007; de Leeuw et al., 2010; Schmid and Dusseldorp, 2010; de Leeuw et al., 2012; Yilmaz and Schmid, 2012). Explanations for this pattern of results typically stress the contribution of bilingual code-switching to language attrition. Code-switching is the term applied to the situations in which "speakers routinely interleave their languages in the course of a single utterance and adapt words from one of their languages in the context of the other" (Green and Abutalebi, 2013). Thus, such findings suggest that the frequency of code-switching on a daily basis may have a more substantial contribution to L1 attrition than the general amount of exposure to L1. It is argued that code-switching contexts lead to co-activation of the two languages in a bilingual mind (Green, 2011), which, in turn, facilitates cross-linguistic interplay between L2 and L1 and thereby accelerates the attrition process (Grosjean and Py, 1991) related to cross-language influence. Conversely, a bilingual speaker who mostly uses L1 in a context where code-switching is rare or discouraged (e.g., in more formal circumstances, such as at work) would experience less co-activation and therefore their L1 performance will exhibit lower levels of attrition.

More evidence supporting the relevance of *quality* rather than *quantity* of L1 exposure over the attrition process comes from a study that investigated L1 attrition *without L2 acquisition* (Baladzhaeva and Laufer, 2018). This study is, to the best of our knowledge, the only investigation of this kind. The study analyzed L1 attrition of lexical retrieval, grammaticality judgments of collocations, and future tense formation in a sample of Russian speakers who emigrated to Israel with no knowledge of Hebrew as L2, and compared them to a group of Russian/Hebrew immigrant speakers as well as to a Russian monolingual group living in Russia. The authors found evidence for L1 attrition in both groups living in Israel, with the no-Hebrew group performing comparable to the Hebrew-speaking group but significantly worse than the monolingual controls in grammaticality judgments. The authors attributed such results to what they named “second-hand attrition”: The extensive contact with the bilingual attriter group caused the monolingual immigrant group to “pick up” L2 influence even without knowledge of L2. This result further supports the notion of major contribution of the *quality* of L1 exposure to the attrition process, as these individuals experienced attrition without any modification in the *quantity* of contact with their L1.

Taken together, the findings reviewed above highlight a key role of the quality of L1 exposure in native language attrition, suggesting that this factor should receive higher consideration in future investigations. In the next section, we attempt to the way forward, taking into account the diversity of available evidence, and suggesting that deploying neuroimaging methods to frame the neural basis of L1 attrition might advance our understanding of this phenomenon.

3. Building a framework: in search of the neural correlates of attrition

Inconsistencies in results and theoretical approaches within the field of L1 attrition underscore the necessity to systematize what is known about attrition and identify common starting points for the future studies. Even more than a common theoretical framework, attrition research requires a methodological boost. Indeed, a stronger emphasis is necessary on ways to elicit generalizable results, eventually leading to an increase in the consistency of studies’ outcomes. As we would like to suggest, one way to achieve this goal may be through the deployment of neuroimaging methods aiming to characterize the *neural basis* of attrition. In the next section, after discussing possible solutions to general methodological issues in the field of language attrition, we suggest potential ways to investigate the neural correlates of the phenomenon in various linguistic subsystems.

3.1. Common practice in attrition research?

In this section, we will briefly describe methodological adjustments that may help us disentangle different hypotheses. One issue that we addressed above regards the causal mechanisms of attrition, i.e. in which measure it could be ascribed to reduced exposure to L1-related factors (i.e. reduced exposure to L1/L1-internal reorganization) or to L2-induced modifications. This issue, as already briefly mentioned, can be tackled with the choice of the optimal experimental samples. Indeed, by comparing attriter populations with matching L1s but differing L2s, one may gain insight on the relative contributions to native language attrition of i) L2-to-L1 cross-linguistic influence and ii) L1-related factors. A pattern of results showing consistency across diverse L2s (all other variables being matched across samples) would provide evidence for the "L1-related" hypothesis, as it is highly unlikely that different L2s, and thus different sets of rules, would produce the same effect on the same L1, in the context of the L2 transfer hypothesis. Thus, such hypothesis would be ruled out. Conversely, results that differ between samples – involving for instance modifications in differing language sub-systems or structures depending on the L2 – would provide evidence in support of the L2 transfer hypothesis, since each different L2 would affect L1 in a peculiar way. Even in the context of failure to provide conclusive evidence (see section 2.1), some examples of this approach are already present in the literature (*e.g.* Schoenmakers-Klein Gunnewiek, 1998; Kopke, 1999).

Note that existing research has failed to detect signs of attrition on several occasions (*e.g.* Jordens et al., 1989; de Bot and Clyne, 1994; Schoenmakers-Klein Gunnewiek, 1998; Hulsen, 2000; Gürel, 2015; Karayayla and Schmid, 2019) or has reported rather minimal evidence in favor of attrition (Altenberg, 1991; de Bot et al., 1991; Olshtain and Barzilay, 1991; Jaspaert and Kroon, 1992; Major, 1992; Kopke, 1999; Hutz, 2004). One way forward could be a more systematic use of neuroimaging methods, since subliminal signatures of attrition at the neural level might already be present when overt behavioral effects may still be undetectable. Another possible way of enhancing sensitivity in detecting attrition is the selection of the appropriate control group as a baseline to which results of the attriter sample can be compared to. An optimal experimental protocol should include a group of individuals who are learning attriters' L1 as a second language (henceforth, *attriter's language learners, AL-learners*) as well as a more "classic" control group of monolingual native speakers. Indeed such practice, when combined with neuroimaging methods, may allow us to pursue signatures of attrition in the brain with enhanced sensitivity. In order to be able to detect slight signs of attrition, one needs to compare attriters' neural responses (the target group) to the responses of two different control groups (i.e., monolingual L1 speakers and AL-learners of different individual proficiency). In this scenario, depending from which control is more similar to the attriters in terms of patterns of neural response, one will be able to infer the absence (if the native speakers) or the presence (if the AL-learners) of attrition in the experimental sample, even in the context of rather subtle changes.

One further suggestion concerns the experimental tasks to be deployed. As we just mentioned, in several studies signs of attrition did not emerge, even when expected. A factor contributing to this inconsistency in findings may be the very low error rates typically shown by attriters even when the attrition process is effectively underway. In her review of this issue, Schmid (2013) has pointed to the issue of error rates, showing that they range between 1% and 5% (see *e.g.* Schmid, 2002; Montrul, 2008; Schmid, 2010; Schmid and Dusseldorp, 2010; Stolberg and Münch, 2010), potentially indicating that the tasks involved are not sensitive enough, or, in other words, too simple to produce many errors. To face this concern, we suggest deploying linguistic tasks of higher complexity, which should help to achieve better separation between the monolingual and the attriting samples and enhance our precision in detecting eventual signs of attrition. Increasing task complexity has indeed been shown to be an effective tool for discriminating slight variations from the norm. An example is the case of syntax comprehension during aging, for which age-related impairments emerge in the face of high task difficulty levels (*e.g.* Peelle et al., 2010, Antonenko et al., 2013), but not at low ones (*e.g.* Tyler et al., 2010).

3.2. Investigating neural correlates of L1 attrition

Up to this point, we have provided some general methodological considerations. We will proceed now to suggest possible ways to investigate L1 attrition in different linguistic sub-systems. Following a brief literature overview, we will propose specific neuroimaging settings for each task in an attempt to isolate the neural correlates of the attrition phenomenon. Before we go into the different sub-systems of language ability, it is important to underline a common principle that we will follow in suggesting each of our perspective tasks. As briefly pointed out above (see section 3.1), L1 attrition research has to rely upon a native monolingual control sample. In this sense, when investigating the neural correlates of L1 attrition, we must take native monolinguals' brain response as a baseline. At this point, given the lack of literature on attrition's neural correlates, we speculate that a working strategy to gain insight into the phenomenon might be to reverse-engineer its nature from the results of second language acquisition studies. After all, multilingualism is indeed a spectrum, a flexible experience: proficiency in each of our languages varies continuously depending on a series of factors, such as the amount of exposure to each language or the new ones we acquire. On one end of this spectrum, L2 acquisition may be described as the process of accommodating an additional linguistic system in our brain. On the other end, attrition may be described as the process of slowly removing one linguistic system (or, more realistically, some sub-components of it) from our brain. Thus, in our view, the process of L1 attrition in the brain should in some way mimic the reversal of proficiency gain in L2. If L1 attrition is characterized by a relative decline in L1 proficiency, then the difference between a L1 attriter and a monolingual speaker at the neural level should resemble/share similarities with the difference between a low proficient and a high proficient L2 learner. L1 performance/processing in attriters should also be associated with ERP and fMRI markers of reduced language proficiency, when compared to their L1 monolingual peers. In other words, in this logic L1 attriters's ERP and fMRI profiles may be similar to bilinguals with lower L2 proficiency. Studies on bilingual language processing highlight that the timing and spacing of brain activity related to L2 processing tend to overlap with the patterns of activity elicited by L1 processing, as L2 proficiency increases. Conversely, as L2 proficiency decreases, more extensive brain activity, as well as reduced and delayed event-related potentials (ERP), are elicited by L2 – compared to L1 – processing (for reviews, see Birdsong, 2006; Abutalebi and Chang-Smith, 2012). Hence, we will suggest tasks that should elicit differential brain responses between monolingual natives and L1 attriters, as well as predictions of ERP signatures and fMRI activation patterns one might expect to see in attriters both at production and language comprehension levels (see Tables 1 and 2, respectively). By means of comparing patterns of brain activity between the putative attriting sample and the monolingual controls, on one hand, and the AL-learners, on the other, we envisage that one would be able to detect the effective presence or absence of L1 attrition.

<Table 1 here>

<Table 2 here>

3.2.1. Lexico-semantic L1 attrition

It is widely accepted that the lexical system is one of the language domains most susceptible to attrition (*e.g.* Kopke, 2002; Schmid, 2011). Lexico-semantic attrition has been broadly documented in speech production - in the form of slow-downs in lexical retrieval, decreases in response accuracy (*e.g.* Olshtain and Barzilay, 1991; Stoessel, 2000; Schmid, 2009; Schmid and Jarvis, 2014), increased frequency and persistence of pauses, repetitions, hesitations, and self-corrections (*e.g.* de Leeuw, 2007; Schmid and Beers Fägersten, 2010; Yilmaz and Schimd, 2012; Schmid and Jarvis, 2014; Bergmann et al, 2015). L1 attrition has also been shown to manifest in impoverished lexical diversity (*e.g.* Laufer, 2003; Yilmaz and Schimd, 2012; Schmid and Jarvis, 2014). Lexico-semantic L1 attrition has been also found to be affected in the comprehension domain, e.g., with poor access to lexical representations during reading (Linck et al., 2009). One important and largely unresolved issue is whether lexico-semantic attrition effects only reflect changes in lexical access or they precipitate into problems with semantic retrieval. Whereas some findings suggest that comprehension of semantic aspects is vulnerable in L1 attrition (Tsimpli et al., 2004), other studies failed to demonstrate L1 attrition in semantic processing, low sensitiveness of paradigms being a potential cause (Scherag et al., 2004).

In regards to language production, different psycholinguistic models have postulated two main stages involved during lexico-semantic access, namely, the *conceptual stage*, taking place from 100-150 ms, during which the semantic concept (i.e., the non-linguistic message) is prepared, and the *lexical stage*, taking place around 150-275 ms and involving the selection of the lemmas and the phonological form to be produced (Levelt, 1999). Studies using ERP methodology provided data supporting this view: whereas semantic effects have been found to modulate the brain signal at a very early time window (~100ms) reflecting the fast access to the concept during speech production (Laganaro et al., 2009; Dell'Acqua et al., 2010), the lexical selection has been registered in a positive waveform peaking later – starting from 200 ms (P2). Importantly, the amplitude of the components reflecting lexical retrieval is inversely correlated with the frequency of the retrieved lemma (*e.g.* Indefrey and Levelt, 2004; Costa et al., 2009; Strijkers et al., 2009; Dell'Acqua et al., 2010; Aristei et al., 2011). Concerning spatial patterns of activation, one particular brain area has emerged to underlie lexical retrieval, namely the mid-section of the left middle temporal gyrus (see Indefrey and Levelt, 2000; 2004 for reviews).

One popular task to investigate the lexico-semantic system during speech production is the picture naming task (see Indefrey and Levelt, 2000; 2004 for detailed reviews on the task). The task is relatively easy to perform, both with EEG/MEG and fMRI methods. A revised version of the picture naming task that may help in the investigation of neural signatures of L1 lexico-semantic attrition is the one developed by Maess and colleagues (Maess et al., 2002). The task is based on the semantic category interference effect, i.e. an increase in naming latencies for sequences of pictures that belong to the same semantic category compared to pictures from different categories. Participants have to name pictures in blocks of either homogeneous or mixed semantic categories. Longer naming latencies are typically recorded in the uniform-category blocks. By contrasting the uniform condition, which taxes the lexical access process to a higher extent due to increased competition, the mixed condition isolates the timing and the spacing of brain activity specific to lexical retrieval (see above). We suggest deploying similar tasks to investigate signatures of L1 lexico-semantic attrition at the neural level, specifically focusing on the early ERP components (~100ms). Alternatively, manipulations of lexical frequency during the picture naming task might be used to compare later (~200ms) differences in the ERP signal after the presentation of high and low frequency words. This would allow elucidation of L1 lexical retrieval in attriters in comparison to control groups in ways similar to what has already been found in anomic patients with lexical and semantic impairments (Laganaro et al. 2009). Comparisons of the intensity and localization of brain activation (e.g. using fMRI) or the timing and the latency of electrophysiological activity (in EEG) between the attriter sample and the two control groups would reflect the presence or the absence of attrition. A larger response overlap of the attriters' neural responses with the monolingual control sample would putatively suggest a lesser degree of attrition in the target group. Conversely, attriters' patterns of neural activity similar to those exhibited by the group of AL-learners would speak in favor of effective signs of L1 lexical attrition.

As for comprehension domain, several EEG studies have demonstrated a cascaded spoken word recognition process with access to the word's meaning taking place in a time window ranging from 200 to 400 ms post stimulus onset (Holcomb and Neville, 1991; Van Petten et al., 1999; Rodriguez-Fornells et al., 2002). This process is supported by a temporo-frontal network of brain regions from the left middle temporal to left inferior frontal gyri (see Friederici, 2012 for a review). Such evidence has been systematically observed as the modulation of the N400, probably the most studied ERP component in relation to word processing. In spoken word recognition, N400 reveals itself as a negative deflection starting around 200 ms and peaking at circa 400 ms following the word onset, typically in semantically incongruent conditions. Similar results have emerged for visual word recognition, with higher N400 amplitudes for words incongruent to the preceding context as well as for meaningless and low-frequency words (Kutas and Hillyard, 1980; Bentin, 1987; Petten, 1993). Additional evidence from semantic priming studies reveals lower N400 amplitudes (more positive) in semantically congruent conditions compared to semantically incongruent ones (Bentin et al., 1985; Deacon et al., 2000; Kiefer, 2002). These effects render the N400 component as a cross-domain neural marker of the relative processing cost associated with lexico-semantic access, particularly useful for the analysis of the prediction and integration processes during word-meaning access (see Kutas and Van Petten, 2006; Kutas and Federmeier, 2011 for reviews). Importantly, the amplitude of the N400 component has been shown to be reduced as a consequence of increasing L2 proficiency, reflecting facilitation in lexico-semantic processing of L2 words due to the learning process (McLaughlin et al., 2004; Borovsky et al., 2010).

The evidence reviewed above suggests that the N400 component might be used as an index of L1 lexico-semantic at comprehension domain, since it is sensitive to modulations in the functioning of the lexico-semantic system as a consequence of language learning. Specifically, opposite patterns of N400 results could be expected in attriters vs. highly proficient L2 learners. Two main paradigms should be considered when exploring the lexico-semantic system in L1 attriters, namely sentence congruency and semantic priming paradigms, typically used to elicit N400. In both, the presentation of L1 words under congruent/incongruent sentence conditions as well as under related/non-related semantic priming conditions could be expected to show smaller N400 effects for attriters and AL-learners than for monolinguals. Furthermore, word frequency effects on N400 would be also expected to differ between groups showing higher effort in the access to lexico-semantic representations of low frequency L1 words in attriters. Such pattern of results would confirm whether the functioning of the lexico-semantic system is affected during L1 language comprehension in attriting speakers showing lower capability to effectively predict and integrate the incoming information into the preceding linguistic context as well as increased effort during accessing lexico-semantic representations of L1 words. Key paradigmatic features to be considered would be the selection of the L1 words associated with a higher processing difficulty and the use of both masked and unmasked priming paradigms. These features would enable analysis of the lexico-semantic attrition at both controlled and automatic processing levels.

3.2.2. Phonological L1 attrition

Attrition of the L1 phonological system has been documented both in language production – in the form of non-native-like pronunciation (*e.g.* Schmid, 2002; Bond Chang, 2010; De Leeuw et al., 2010; De Leeuw et al., 2018), and in comprehension –affecting the ability to distinguish between L1 phonemes (*e.g.* Ventureyra et al., 2004; Cancila et al., 2005**)** or to judge foreign accents in L1 (Major and Baptista, 2009).

Two main phonological processes in language production are considered to take place following the point of lexical selection, namely phonological encoding and phonetic/articulatory preparation. Research using monolingual samples consistently shows a time window between 275 and 450 ms for brain activity related to phonological encoding, which is followed by phonetic encoding and motor articulation processes in the 450 to 600 ms window (e.g. Eulitz et al., 2000; Indefrey and Levelt, 2004; Laganaro et al. 2009; Sahin et al., 2009; Dell'Acqua et al., 2010). Furthermore, fMRI studies have successfully isolated a left-lateralized network that supports phonological processing comprising Wernicke's area, the inferior parietal lobule, and Broca's area (e.g. Dehaene-Lambertz et al., 2002; Heim and Friederici, 2003; Démonet et al., 2005).

Analysis of the electrophysiological and the hemodynamic activity during picture naming and picture-interference tasks by means of EEG/MEG and fMRI methods could provide valuable information about the neural markers of L1 attrition of phonological encoding. The logic is similar to the one described above for the evaluation of lexico-semantic L1 attrition. In case of phonology, the manipulation of lexical and particularly phonological variables should be taken into account as well as the comparison of L1 attriters to both L1 monolinguals and AL-learners. For instance, analysis of the phonological facilitation effects by means of a picture-word interference paradigm could allow us to identify specific neural patterns of phonological attrition in L1. Under this manipulation (see Mahon et al., 2007 for a review), participants are asked to name a picture which is superimposed with a phonologically related word, which in turns facilitates the activation of the related phonological representations. This effect has been found to modulate the ERP signal starting around 300 ms post-stimulus onset and reflecting facilitation of phonological encoding (Dell' Acqua et al., 2010). Accordingly, reduced phonological facilitation effects reflected in the modulation of a late ERP time window (starting from 300 to 450 ms) would be expected in attriters in comparison to monolingual controls. This would be indicative of impaired encoding of phonological word forms in L1. A signature of attrition could be also revealed in case comparable phonological facilitation effects are observed in attriters and AL-learners.

In language comprehension, phonological processing takes place earlier than in language production, potentially reflecting the reverse process of phonological access. Indeed, the recognition of phonemes during speech perception emerges in native listeners as early as around 50 ms following stimulus onset (Palvaet al., 2002). This phonological process is often reflected in the modulation of the so-called mismatch negativity (MMN) effect. MMN is an auditory event-related potential associated with general auditory perception and it has been specifically related to the automatic brain's capacity to detect changes during auditory perception with minimal attention allocation (see Näätänen et al., 2007, for a review). More specifically, MMN is defined as a negative potential which increases around 150-250 ms after the presentation of a deviant sound and whose neural generator is typically found in the auditory cortex (Kropotov et al., 1995; 2000; Opitz et al., 2005; Rosburg et al., 2005). Several EEG/MEG studies have systematically reported a modulation of the MMN during the presentation of the standard-deviant stimuli (phonemes as well as of syllables and whole words) but, importantly, only in the listener's native phonology (Dehaene-Lambertz, 1997; Näätänen et al., 1997; Shtyrov et al., 1998; Pulvermüller et al., 2001a; Shtyrov, Kujala, Palva, Ilmoniemi and Näätänen, 2000). In this sense, the MMN modulation is a neural correlate of the accuracy of the phonological system in recognizing native phonological patterns – by means of forming language-specific sound memory traces through the exposure to a native language during the first (6-12) months of life (Cheour et al., 1998). Interestingly, changes in the modulation of the MMN have also been shown to reflect acquisition of new phonological representations in L2, with shifts from no initial MMN modulation to enhancements linked to increased L2 proficiency (Tremblay et al., 1998; Winkler et al, 1999; Cheour et al., 2002; Nenonen et al., 2005). For instance, it has been shown that L1 Hungarian/L2 Finnish speakers produce higher MMN modulation in response to Finnish phonemes than Hungarian monolinguals but similar to the native speakers of Finnish (Winkler et al., 1999). This pattern suggests that the formation of phoneme representations for the foreign language is a consequence of repetitive experience through learning. In this sense, the reverse pattern of results could be expected in L1 attrition if the ability to effectively discriminate native phonology is reduced in attriters.

We suggest that an appropriate task aimed at evaluating the presence of L1 attrition in phonological processing during speech comprehension would call for using the oddball paradigm as in the aforementioned studies. Recording EEG or MEG signals during the presentation of standard and deviant sounds (using L1 phonemes, syllables or words) and with increased differences between the two types of stimuli would provide useful information about the discrimination of language sounds in the native language. If the accuracy of attriters' phonological system is reduced, then we would expect them to show a lower modulation of the MMN during the presentation of L1 stimuli than monolingual controls. In particular, higher stimulus deviation might be required to elicit the MMN in attriters, suggesting impoverished discrimination of phonetic patterns in the native language. Moreover, attriters would be expected to show performance similar to AL-learners, confirming the presence of phonological L1 attrition for auditory language comprehension.

We also propose the use of fMRI to investigate the brain regions involved in phonological L1 attrition during speech comprehension, following the study by Callan et al.'s (2004). Callan and colleagues investigated differential brain activation patters related to processing of the /l/-/r/ phonetic pair in native English speakers for whom the contrast is very easy to detect as well as in Japanese-English bilinguals, who lack the distinction between these two phonemes in their native language. The stimuli were English syllables beginning with /r/ or /l/ (followed by different English vowels), vowels presented alone, and baseline trials consisting of silence. Participants had to identify whether the stimulus started with /l/, /r/, or a vowel. After a practice session outside of the scanner, stimuli were presented in an fMRI scanner during acquisition in an event-related design. Callan and colleagues reported overlapping activation loci between the two groups for /r/ and /l/ phoneme identification; however, the Japanese native speakers showed significantly higher brain activation. The corresponding neural network included superior and medial temporal areas, Broca's area, anterior insula, premotor cortex, cerebellum, and basal ganglia – regions known to be involved in phonetic processing, speech planning, and articulatory mapping. The additional activation reported for the non-native speakers is thought to underlie increased effort to overcome difficulties in L2 phoneme identification. Japanese participants also activated executive control areas known to be linked to inhibition of the interference from a dominant L1 during L2 processing in bilingual participants (see e.g. Green and Abutalebi, 2013). This study offers a useful model for assessing phonological L1 attrition as well as a representative baseline. A phonemic contrast on the L1/L2 pairs of the attriter sample and comparison of the elicited pattern of brain activation to monolingual and AL-learner samples would allow to test for the presence or absence of attrition.

3.2.3. L1 attrition of grammar

L1 attrition of grammar has been previously shown in the form of intrusion effects of the L2 grammar on the L1 grammar as well as reductions and simplifications in the L1 morpho-syntactic system in both production and comprehension modalities (*e.g.* Altenberg, 1991; Ben Rafael, 2004; Gürel, 2004; Schmid, 2014; Kasparian et al., 2017; for a review, see Gürel, 2008).

Regarding language production, it has been found that the encoding of syntax during speech production engages the activation of frontal as well as motor areas in sentence generation tasks, particularly the left inferior frontal gyrus (BA 44/45) and the left anterior part of Rolandic operculum (BA 6), caudally adjacent to Broca's area (Indefrey et al., 2001; Haller et al., 2005; Tremblay and Small, 2011). A few electrophysiological studies have also contributed to the understanding of brain dynamics during syntax encoding, some of them suggesting these processes take place around 400 ms once conceptual information has been already activated, following a serial or cascaded processing during speech (Schmitt, Schiltz, Zaake, Kutas, and Münte, 2001; Schmitt, Rodriguez-Fornells, Kutas, and Münte, 2001).

However, syntactic processes have been much more studied at language comprehension domain. Thus, there is general agreement that morphosyntactic processing during language comprehension is mediated by a fronto-parietal, left-lateralized brain network comprising the posterior portion of Broca's Area (BA 44), and the posterior superior temporal gyrus/sulcus dorsally associated through the arcuate and the superior longitudinal fasciculi (for reviews, see Friederici et al., 2006; Cappa, 2012). Moreover, several EEG studies have identified a set of ERP components related to different stages of syntactic processing during language comprehension in both spoken (Friederici, 2002) and visual (Molinaro et al., 2011) perception modalities. For instance, violations of phrase structure rules have been found to elicit modulations in brain activity as early as 150-200 ms post stimulus onset reflected in an Early Left Anterior Negativity (ELAN). This component has been related to the initial processing stage of the syntactic structure building, albeit the debate about the reliability of ELAN as a signature of syntactic analysis continues (for a review, see Steinhauer and Drury, 2012). In comparison, the Left Anterior Negativity (LAN) has been more systematically found at later latencies – around 300 ms – and it is related to difficulties with integrating morphosyntactic information during the subsequent stage of thematic role assignment (Friederici et al.,1993; Friederici and Frisch, 2000; Gunter et al., 2000). At the same time, the N400 component, previously reviewed in relation to lexico-semantic processes, has also emerged during sentence-level violations, particularly related to difficulties in semantic integration (for a review, see Hahne and Friederici, 2002) and thematic role assignment (Frisch et al., 2004). Finally, the P600 component, a late centro-parietal positivity, has been linked to syntactic revision and reanalysis processes during the final stages of syntactic integration (*e.g.* Gouvea et al., 2010; for a review, see Friederici and Weissenborn, 2007).

The timeline, chronometry, and the neural generators of the syntactic processing effects have been traditionally investigated by means of grammaticality judgment tasks and with the help of EEG/MEG or fMRI methods. In such tasks, participants are presented with grammatical and ungrammatical sentences that they have to rate for their acceptability. Importantly, the detection of grammatical violations in the non-native language has been reported to modulate both early and late syntax-related ERP components showing a gradual acquisition of the L2 grammar rules (Rossi et al., 2006; Batterink and Neville, 2013; Tanner et al., 2013). With regard to L1 attrition, a reverse-engineering approach might once again help us to determine whether L1 syntactic processing is affected in attriters and which specific neural sub-processes are at disadvantage. This goal can be achieved by investigating differences and commonalities of ERP syntactic effects between attriters, on the one end, and monolinguals and AL-learners, on the other.

As a recent example of this ERP-comparison approach, a study by Kasparian et al. (2017) investigated attrition of L1 grammar in a sample of Italian native speakers who emigrated to Canada in their adulthood. Participants were presented with a grammaticality judgment task with simultaneous EEG recording. The study revealed differences in amplitude, scalp distribution, and duration of LAN, N400, and P600 components between the L1 Italian/L2 English attriter' group and an Italian monolingual control group providing evidence for the presence of L1 attrition at the neural level. Kasparian and colleagues' approach represents a useful model to follow in L1 attrition research, although the inclusion of a group of AL-learners needs to be considered in order to allow more detailed comparisons.

We are unaware of any grammar attrition study using fMRI methodology; however, considerations and predictions similar to the ones already offered above can be applied. Existing fMRI studies show that syntactic processing relies upon a more extensive neural network in low proficient bilinguals compared to monolinguals, both in the form of increased activity in Broca's area and in the activation of additional surrounding areas only for the bilingual group. Nonetheless, with increasing levels of L2 proficiency, the pattern of neural activation related to grammar processing in bilinguals has been shown to approximate that of monolinguals (for reviews, see Birdsong, 2006; Indefrey, 2006; Abutalebi, 2008). These results from bilingualism literature enable us to make predictions about putative neural signatures of grammatical processes in L1 attrition (see section 3.2). As the process of attrition progresses, we may expect the attriters' pattern of neural activation during L1 syntax processing to increasingly approximate that of low proficient AL-learners. Both groups, compared to L1 native speakers, are expected to exhibit stronger activity in Broca's area, as well as activity in additional areas surrounding it.

4. Conclusions

The present paper provides an attempt at a systematic analysis of the L1 attrition phenomenon with specific foci on existing theories and methodological considerations. We discuss important methodological and practical parameters of the existing research, and suggest how these parameters may be improved in the future studies. We believe that these future studies will need to isolate the neural underpinnings of L1 attrition, therefore shedding new light on the nature of the phenomenon. L1 attrition has been reported to affect all of the main subsystems involved in language processing with changes ranging from lexico-semantic and phonological to the morphosyntactic levels of processing both in the production and comprehension modalities. Despite its impact, the nature and the specific causes for the loss of the native language capacity in attriting populations remain unclear. A number of factors have been hypothesized to cause L1 attrition including the amount and quality of L1 exposure, the attitudes towards L1, and the cross-linguistic influence exerted by the L2. At the same time, little evidence has been provided that would unequivocally support either of these hypotheses. Moreover, there is very little research investigating the specific brain mechanisms underlying the attrition phenomenon. The majority of available studies are focused on the behavioral signatures of attrition with little attempt to explore the neurophysiological mechanisms underlying this process.

Above, we offered two important future considerations that have a potential to improve our knowledge of the attrition phenomenon. First, we propose an "audit" of existing theoretical proposals based on two potential attrition mechanisms: one based on L1 disuse and the other – on L2 intrusion. Second, we outlined a systematic approach to this phenomenon using neuroscientific methods that could potentially elucidate attrition at the neural level. This new research will prove fundamental to our understanding of the nature of attrition and its underlying brain mechanisms. A theoretically informed and methodologically sensitive choice of a specific neuroimaging technique, experimental procedures, and control groups is crucial for the advancements in the field of L1 attrition. A detailed profile of the attriter's L1 should be investigated using fine-grained methods, taking into account a complex array of the affected processes and systems, some of which are triggered within a few hundreds of milliseconds. The use of neuroimaging tools which allow detailing brain activation with a high temporal resolution, such as EEG/MEG, could be particularly relevant for future research, as language is highly dynamic phenomenon, requiring equally dynamic research techniques (Shtyrov and Stroganova, 2015).

Finally, we suggest the use of specific experimental manipulations and tasks based on corroborating evidence from monolingual and bilingual populations. Most importantly, we emphasize the relevance of using both L1 monolinguals and AL-learners as key control groups to effectively determine the presence or absence of L1 attrition in a framework that sees L1 attrition as the reversal of L2 acquisition. Importantly, the study of attrition in the absence of contact with L2 should be granted more consideration from further research, in order to clarify whether native language attrition is actually caused by cross-linguistic influence or by internal processes related to L1 reorganization. Hopefully, this future-oriented review will constitute the first step towards more detailed and more generalizable findings in this relatively young yet important research field.

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Table 1. Predictions of brain activity patterns during language production obtained by means of functional neuroimaging methods at corresponding anatomic-structure and dynamic-temporal levels. Predictions are proposed for an attriter sample in comparison with their corresponding L1 monolingual controls. Note that, conversely, the attriter pattern would also resemble that obtained by a group of L1-learners.

<table>
<tr><th rowspan="2">LINGUISTIC SUBSYSTEM</th><th rowspan="2">TASK AND
PROCESS INVOLVED</th><th colspan="2">BRAIN ACTIVITY PATTERN</th></tr>
<tr><th>SPATIAL LOCALIZATION (fMRI)

(+) ACTIVATION INTENSITY
(+) ACTIVATION SPREAD</th><th>TEMPORAL DYNAMICS (EEG/MEG)

(-) AMPLITUDE
(+) LATENCY</th></tr>
<tr><td rowspan="2">LEXICO-SEMANTIC</td><td rowspan="2">Picture naming task:
Conceptual access and lexical retrieval processes</td><td rowspan="2">Left Middle Temporal Gyrus
Left Inferior Frontal Gyrus</td><td>~100 ms (conceptual access)</td></tr>
<tr><td>~200 ms (P200, lexical selection)</td></tr>
<tr><td>SYNTAX</td><td>Scene description task, syntactic decision task:
syntactic encoding processes (selection of word class and grammatical gender, specification of words relations and inflectional marks)</td><td>Left Inferior Frontal Gyrus
Left Rolandic Operculum</td><td>~400 ms
(syntactic encoding)</td></tr>
<tr><td rowspan="2">PHONOLOGY</td><td rowspan="2">Picture naming task, picture-word interference paradigm:
Phonological encoding and phonetic/articulatory preparation</td><td rowspan="2">Left Inferior Frontal Gyrus
Premotor Cortex</td><td>~300 ms
(phonetic encoding)</td></tr>
<tr><td>~450 ms
(motor articulation, syllabification)</td></tr>
</table>

Table 2. Predictions of brain activity patterns during language comprehension obtained by means of functional neuroimaging methods at corresponding anatomic-structure and dynamic-temporal levels. Predictions are proposed for an attriter sample in comparison with their corresponding L1 monolingual controls. Note that, conversely, the attriter pattern would also resemble that obtained by a group of L1-learners.

LINGUISTIC SUBSYSTEM	***TASK AND PROCESS INVOLVED***	***BRAIN ACTIVITY PATTERN***	
		SPATIAL LOCALIZATION (fMRI) (+) ACTIVATION INTENSITY (+) ACTIVATION SPREAD	***TEMPORAL DYNAMICS (EEG/MEG)*** (-) AMPLITUDE (+) LATENCY
PHONOLOGY	Phoneme identification task, oddball paradigm: Recognition of phonological patterns	Left Superior and Medial Temporal Gyri Left Inferior Parietal Lobule	~150 ms (MMN, phonological discrimination)
LEXICO-SEMANTIC	Categorization/Judgement task, sentence congruency/semantic priming paradigm: Conceptual access, word prediction and integration	Left Middle and Superior Temporal Gyri	~400 ms (N400, conceptual access)
SYNTAX	Grammatically Judgement task: syntactic comprehension processes (building syntactic structure, thematic role assignment, integration and reanalysis processes)	Left Inferior Frontal Gyrus Posterior Superior Temporal Gyrus Sulcus	~150 ms (ELAN, building of syntactic structure)
			~300 ms (LAN, morphosyntactic integration)
			~400 ms (N400, thematic role assignment)
			~600 ms (P600, syntactic revision and reanalysis processes)

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