

## Linguistic Regression in Bilingual Patients with Alzheimer's Disease

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### Abstract and Keywords

Since attrition is generally defined as non-pathological loss of a language, comparisons with acquired language disorders, namely Alzheimer's Disease (AD), however fruitful they may be, are a largely neglected area in attrition research. One of the characteristics of neurodegenerative diseases is the gradual continuous loss of cognitive skills raising theoretical questions which are also highlighted by language attrition research. The vulnerability of languages acquired at different moments of life (L1, L2, L3...) has received most attention. Another question concerns the evolution of cognitive skills related to language control in demented patients as reflected in the specificities of code-mixing behaviour in bilinguals with AD. The hypothesis of protective effects of bilingualism in healthy and pathological cognitive ageing is then discussed. We suggest that further taking into account of the interaction between memory and language in cognition and language processing, as in studies on AD, may be beneficial for attrition research.

Keywords: language attrition, linguistic regression, Alzheimer's Disease, bilingualism, cognitive control, cognitive reserve, language mixing

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## 13.1 Introduction

WHILE language *attrition* is frequently defined as the non-pathological loss of a language, pathological linguistic *regression* can be observed in individuals with acquired or degenerative language disorders, especially Alzheimer's Disease (AD), and constitutes a promising research avenue in order to elucidate parallels between pathological and non-pathological language changes across the lifespan. Such comparisons are not completely new in the field of language, the most famous example being Jakobson's (1941) monograph advocating the exploration of parallels between different diachronic processes of language change (i.e., first language (L1) acquisition and language loss following stroke) in order to find evidence for language universals. Parallels between language change across time and language development across an individual's lifespan are traditionally ex-

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plained by *recapitulation*, and those between language acquisition and loss by *regression*, both theories being based on the notions of continuity, gradualness and unidirectionality (de Bot & Weltens, 1991, p. 33). These notions have, however, been comprehensively challenged by more recent frameworks such as Dynamic Systems Theory (de Bot, 2007).

The concept of *regression* is particularly useful in research on both attrition and acquired language disorders. With respect to aphasia in monolinguals, however, the investigations reported by Caramazza & Zurif (1978a) clearly showed that there is no regression in the dismantling of linguistic structures in aphasia, except for segmental phonology (cf. de Bot & (p. 137) Weltens, 1991). With respect to aphasia in bilinguals, Obler & Mahecha (1991) sought to establish links between the bilingual profiles and recovery patterns of patients with aphasia, in order to see whether the latter reflect the order in which the languages were acquired. They concluded that the order of language recovery in these patients depended more on specific brain organization than on extralinguistic factors—a hypothesis that is also relevant to non-pathological attrition. However, aphasia following a stroke may not be the best model for studying regression patterns, as it typically occurs suddenly and may affect only specific aspects of verbal behaviour.

In non-pathological attrition research, regression was first mentioned in the language reversion hypothesis put forward by de Bot & Clyne (1989), whereby elderly migrants are 'increasingly more likely to return to their L1, while at the same time losing parts of their L2' (Keijzer, 2011, p. 221). This hypothesis was not, however, confirmed in subsequent studies. Other authors have investigated the *first in, last out* principle, but results have been mixed (Köpke & Schmid, 2004). Findings suggest that regression may be more likely in the context of L2 attrition, and affects only specific linguistic domains. With respect to L1 attrition, Keijzer's (2010b) results indicate that regression patterns concern only very specific aspects of verb and noun morphology and syntax, with other linguistic domains seemingly either resilient to attrition or following different patterns.

Studies exploring regression patterns in language disorders and establishing parallels between different types of language loss are still strikingly absent. As early as 1983, Obler suggested that language dissolution in the context of dementia might be an interesting model for studying regression. This is the avenue we have chosen to pursue here. The topic is also extremely timely, given the rising incidence of AD and the growing number of people who regularly speak two or more languages (European Commission, 2012). Even so, little is known about disease progression in bilingual/multilingual individuals with AD, and specifically about how the disease affects the different languages they speak. This issue is not solely important from a public health perspective; a better understanding of language dissolution processes in language disorders can also inform theories on language attrition and language processing in bi- and multilingual populations.

# 13.2 Alzheimer's Disease, language, and bilingualism

## 13.2.1 Alzheimer's Disease

AD, the most common neurodegenerative disease, used to be placed under the more general heading of *dementia*. In 2011, the National Institute on Aging and the Alzheimer's Association workgroup proposed updated recommendations for AD diagnosis (McKhann et al., 2011). More recently, in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013), a standard nomenclature used by clinicians and researchers for the classification of mental disorders, the term of *dementia* has been replaced by two new terms: *major neurocognitive disorder* and *mild neurocognitive disorder*. The new diagnostic criteria for these disorders focus less on memory impairment, allowing for variables associated with conditions that sometimes (p. 138) begin with declines in speech or language. According to the DSM-5 criteria, the main difference between major and mild neurocognitive disorders is that individuals with the former exhibit deficits in cognitive functions (complex attention, executive function, learning and memory, language, perceptual-motor or social cognition) that interfere with their independence.

A number of different pathologies meet this definition, notably frontotemporal lobar degeneration, Lewy body disease, vascular disease, and Parkinson's disease. The DSM-5 states that patients should be diagnosed with AD if the following conditions are fulfilled: (i) criteria met for major neurocognitive disorder; (ii) insidious onset and gradual progression of impairment in one or more cognitive domains; (iii) evidence of a causative genetic mutation from family history or genetic testing; and (iv) clear evidence of a decline in memory and learning and at least one other cognitive domain.

## 13.2.2 Language deterioration in monolingual patients with Alzheimer's Disease

It is now generally accepted that language abilities are selectively impaired at different stages of AD. Viewing language deterioration as a reduction in language proficiency, Lefebvre & Rinaldi (2015) correlated it with disease progression. For example, anomia in picture naming is characteristic of patients in the early phase of the disease, but semantic memory remains relatively spared. Patients' language production in the moderate phase of AD is characterized by semantic paraphasia, correlated with deteriorating semantic memory. Finally, patients in the severe phase of AD become mute, or only able to produce verbal automatisms. Language difficulties initially occur at the lexicosemantic and discursive levels, with syntax and phonology (and therefore repetition) being relatively spared until the moderate/severe phase. In summary, with respect to oral language skills, production, and comprehension difficulties are positively correlated with disease severity. The picture is slightly different for written language skills: writing is impaired at the beginning of the disease, but the ability to recognize letters and words, and to orally

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produce them, is sometimes preserved until the most severe phase, although their meaning is no longer understood.

### 13.2.3 Bilingualism and Alzheimer's Disease: a topic of growing interest

The issue of language regression in bilingual individuals with AD has recently attracted considerable interest from researchers. To assess the growing attention paid to this topic over the past decade, we carried out a scientific literature search on the Web of Science covering the years 2000 to 2019. The following search string was used as keywords for study retrieval: 'Alzheimer' OR 'Dement\*' AND 'Bilingu\*'. This investigation yielded 113 different references and revealed that the focus on language change in bilingual patients with AD came in the wake of Bialystok et al.'s (2007) publication about lifelong bilingualism protecting against the onset of AD (Figure 13.1). Since then, the number of studies addressing the question of AD in multilingual/multicultural contexts has grown steadily.

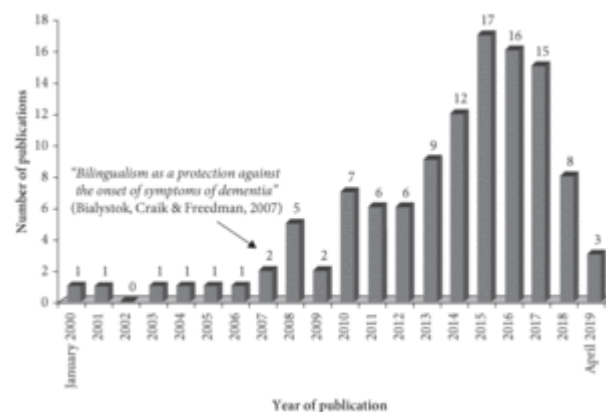


Figure 13.1. Number of publications (from January 2000 to April 2019) responding to BILINGU\* AND ALZHEIMER OR DEMENT\* keywords on WoS (N = 113)

(p. 139) Although the number of studies of the cognitive benefits of bilingualism and the relationship with cognitive reserve in dementia has increased exponentially (see also *infra* 12.3.1), the question of how ageing affects bilingual populations' linguistic skills has yet to be properly explored. This may be because of the misinformed idea that language skills are little affected by ageing (Hupet & Nef, 1994). Even so, bilingual individuals pose a major challenge for health and social care provision, because existing tools for assessment and rehabilitation are not adapted for bilingual speakers. Hence, it is essential to examine the disease's impact on bilingual linguistic skills, in order to develop tailored interventions and, more fundamentally, to understand the involution process within a single framework linking the cognitive functioning underlying bilingualism with that underlying language.

Research on bilingual speakers with AD has raised theoretical questions that have also been highlighted in language attrition research. The issue of the vulnerability of languages acquired at different times of life (L1 versus L2, L3, etc.) has received by far the most attention. Another question concerns changes in the cognitive skills related to language control in patients with dementia, with a number of studies focusing on the specificities of code switching behaviour in bilinguals with AD. Moreover, whereas the impact of AD on memory and language is constantly questioned in studies of this disease, this is less the case in attrition studies, for while psychologists tend to define attrition as a memory problem, linguists seek its origin in the structure of language. Taking account of the interweaving of memory and language in language processing would certainly be beneficial for further research on attrition.

### (p. 140) **13.3 Alzheimer's Disease and bilingualism**

#### **13.3.1 The Babylonian benefit: a controversial issue**

The pioneering study by Bialystok et al. (2007) suggested that bilingualism helps to delay the onset of AD, arguing that lifelong bilingualism creates a cognitive reserve (stemming from inhibitory processes associated with bilingualism, see Section 13.3.3 below) that offsets the symptoms of AD. Since then, a growing body of literature has addressed this issue, but discrepant findings have triggered fierce controversy. When Bialystok et al. (2007) examined a pool of monolingual and English-French bilingual individuals, two-thirds of whom had been diagnosed with AD, they found that the symptoms of AD occurred 4.1 years later in bilinguals than in monolinguals. Although their finding was subsequently confirmed by a couple of studies evidencing a delay of four to five years in bilingual individuals (Alladi et al., 2013; Craik et al., 2010; Woumans et al., 2015), several studies failed to replicate these results (Crane et al., 2010; Sanders et al., 2012; Zahodne et al., 2014; Lawton et al., 2015), while others only partially replicated them, thus casting doubts on the relationship between bilingualism and cognitive reserve. Chertkow et al. (2010), for instance, found a small but significant beneficial effect in speakers of more than two languages (i.e., multilinguals), but not in bilinguals. Similarly, Hack (2011) found that only individuals speaking four or more languages had a significantly lower chance of developing AD than monolinguals.

There are many possible explanations for these contradictory findings, as bilingualism is associated with many potential confounding variables, such as immigration and socio-economic status (Bak, 2016). Regarding the latter, Gollan, Salmon, et al. (2011) only found delayed AD in bilinguals with a low education level, whereas the study conducted by Alladi et al. (2013) in India suggested that cognitive benefits are unrelated to education level. Moreover, several studies in which bilingualism was not confounded by migration status still reported a beneficial effect of bilingualism in healthy and pathological ageing populations (Alladi et al., 2013; Bak et al., 2014; Perquin et al., 2013; Woumans et al., 2015). Methodological biases (e.g., lack of objective assessment of language proficiency or monolingualism, differences in sample size, variability of instruments used to assess cog-

nitive skills and diagnose AD) are nonetheless likely to account for these discrepant findings (Ghazi-Saidi & Ansaldi, 2015; Lawton et al., 2015; Calvo et al., 2016). In addition, some of these studies only included patients with AD, whereas others also included those with mild cognitive impairment (MCI; e.g., Kowoll et al., 2015) or other types of dementia (e.g., Alladi et al., 2013). Finally, examination of other variables known to affect cognitive reserve, such as social networking or sustained intellectual stimulation across the lifespan, were not always controlled for. While Calvo et al. (2016) stress that these shortcomings do not mean that bilingualism does not play a role in cognitive reserve, they insist on the need for better controlled experimental designs, in order to understand the relationship between bilingualism and cognitive reserve more clearly. Interestingly, the notion of cognitive reserve has never been taken into account in attrition research, just as possible language attrition is never mentioned in studies of ageing (cf. Higby et al., Chapter 12, this volume).

### (p. 141) 13.3.2 Second-language regression in Alzheimer's Disease

Monolinguals with AD are disproportionately impaired relative to controls when naming pictures with low-frequency, low-familiarity, low-imageability, and late-acquired names (e.g., Ivanova et al., 2013). Thus, words that are weakly represented may decline more quickly and at an earlier stage in the disease than more robustly represented words. Similar claims have been made with respect to language attrition (Datta, 2010). Although they are based on evidence from monolingual patients, these findings allow us to derive hypotheses about the naming performances of bilinguals with AD. If their two languages are equally robust (i.e., *balanced* bilinguals), they presumably decline at the same rate and over the same time course. Extant evidence is consistent with this prediction. Conversely, in non-balanced bilinguals, we would expect the weaker language to decline more quickly than the dominant one, based on the assumption that producing words in the non-dominant language requires greater executive control to overcome competition from translation equivalents in the dominant language (cf. Green, 1986, 1998; Bialystok, 2009). Given that executive control declines in AD (Perry & Hodges, 1999; Bäckman et al., 2004; see also Köpke & Keijzer, Chapter 7, this volume), L2 production is presumably more impaired throughout the course of the disease than L1 production.

There is consistent evidence that the ability to maintain a good command of the L2 tends to decrease with ageing (Hyltenstam & Obler, 1989), even in healthy ageing individuals who have been bilingual all their lives (cf. Higby et al., Chapter 12, this volume). This decline is greater in bilinguals with AD, who exhibit greater regression in their L2, while the L1 is preserved for longer. In the study by Mendez et al. (1999), patients with AD who had been exposed to English as an L2 from the age of 13 onwards, showed a clear preference for their L1, regardless of L2 age of acquisition and frequency of use. In a study of patients with AD who were born in Finland but migrated to Sweden, communication in Swedish (L2) was found to be more difficult than communication with caregivers speaking the patients' L1 (Ekman et al., 1993; Ekman, 1996). Dronkers et al. (1986) reported the case of a patient who initially had a good command of both Dutch (L1) and English (L2 acquired during adulthood), but who displayed an increasing preference for the L1 as

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the disease progressed. The hypothesis of L2 regression is also supported by Ivanova et al. (2014), who studied a pool of thirty-one bilinguals with probable AD whose L2 (English learned after age 13) showed a greater decline than their L1. This was established by interviewing the patients' caregivers, who reported that the patients reverted to using their first-learned language as the disease progressed, with more and more L1 intrusions when communicating in the L2. Thus, for these bilinguals, the late-acquired language appeared to be particularly vulnerable to the effects of AD. By contrast, the pattern reported by Gollan et al. (2010) for their bilingual participants with AD was not consistent with the theoretical framework of L2 regression outlined above. These authors compared the picture-naming performances of Spanish-English bilinguals with those of matched bilingual controls. Results show that the English-dominant bilinguals with AD had higher naming scores when credited for pictures named in the L2 that they could not produce in their L1—the opposite pattern to the one found by Ivanova et al. (2014). The same trend was observed for Spanish-dominant (p. 142) bilinguals with AD, although statistical analysis revealed an equivalent decline in both languages relative to controls. An equivalent decline was found by Salvatierra et al. (2007), who administered a verbal fluency task to Spanish-English bilinguals with AD and controls. Thus, neither bilingual group in the studies by Gollan et al. (2010) and Salvatierra et al. (2007) exhibited the *first in, last out* principle, according to which the L1 should be less vulnerable to disease effects. Instead, in these studies, either the L1 was more affected, or the two languages were equally affected. For their part, Gómez-Ruiz et al. (2012) examined early bilingual patients with AD and a bilingual control group in Catalonia. Half the participants were early simultaneous bilinguals, while the other half had acquired Catalan before Spanish. Language skills were assessed using the Spanish and Catalan versions of the bilingual aphasia test (BAT; Paradis et al., 2008), and results showed similar language deficit patterns in both languages and for both groups of bilinguals. Likewise, when Costa & Sebastián-Gallés (2012) investigated Catalan-Spanish bilinguals with AD, they found that these two languages were similarly affected by the disease, relative to those of a control group consisting of twenty-four bilinguals with MCI.

A number of methodological differences could explain these discrepant results. First, language skills were assessed with different tasks, with Mendez et al. (1999) relying on caregivers' reports of declines in connected speech over time, Gollan et al. (2010) assessing picture naming in both languages at a single point in time, and Salvatierra et al. (2007) measuring semantic and phonological fluency. To overcome this apparent discrepancy and further elucidate the pattern of decline in bilinguals' two languages, Ivanova et al. (2014) investigated both longitudinal and cross-sectional patterns of linguistic decline in non-balanced bilinguals with AD, administering the Boston Naming Test in both languages (Kaplan et al., 1983) over a three-year period. Their main findings were that the decline in the L1 and L2 followed different patterns cross-sectionally and longitudinally. More specifically, longitudinal analyses of patients' naming scores (no comparisons with controls) showed that the L2 declined more steeply than the L1. By contrast, cross-sectional comparisons revealed greater differences between patients and controls on L1 than on L2 tasks. Taken together, these results suggest that both languages are affected by

AD, but may follow different decline trajectories over the course of the disease. To determine whether the L1 declines more than the L2, Kowoll et al. (2015) compared patients with MCI and AD ( $n = 47$ ) and healthy controls classified as lifelong bilinguals on different neuropsychological tasks. Although only minor, non-significant differences in neuropsychological profiles emerged between mono- and bilingual participants when the diagnostic groups were compared; the bilingual patients with MCI scored significantly lower on verbal fluency and picture naming in their L1 than the controls. As for the patients with AD, they performed less well in their L2 than patients with MCI and bilingual controls. These results suggest that the first acquired language is compromised first in bilingual patients with MCI, with severe L2 deficits emerging after AD onset. To summarize, the general trend emerging from the literature is consistent with the hypothesis of L2 regression and better L1 preservation, especially in the case of late bilingualism. This pattern is consistent with the predictions of the declarative/procedural model (Paradis, 2009; see Köpke & Keijzer, Chapter 7, this volume), which assumes greater involvement in processing for later learned languages, and hence greater vulnerability of the latter in the case of AD.

### (p. 143) 13.3.3 Language mixing in bilingual individuals with Alzheimer's Disease

The way in which bilingual individuals select an appropriate language for communicating is one of the major issues in bilingualism research. Bilingual patients with AD regularly display specific difficulties related to language mixing (or code mixing). These difficulties include (i) language choice, (ii) separation of languages, (iii) code switching, and (iv) borrowing—all skills that healthy young bilinguals manage without difficulty (Grosjean, 2001). Even from a very early stage, AD seems to affect the ability of bilingual patients to make these choices appropriately, according to the communication situation (Friedland, 1998). For example, Dronkers et al. (1986) described a polyglot patient speaking Dutch (L1), French (L2 learned during adolescence), and English (L3, learned in adulthood) who performed better in Dutch and English (i.e., dominant languages in her environment) than in French, but preferred to use her L1 in conversational settings. This patient showed a marked tendency to mix Dutch and English, and sometimes even used Dutch when her interlocutors did not share this language. De Vreese et al. (1988) conducted a similar study with a trilingual patient with severe AD. In addition to Italian (L1), he had also mastered French (acquired at school at the age of 13 years) and English (learned at the age of 28 years). Results revealed that in conversational settings, the patient's performance followed the order of acquisition (i.e., Italian > French > English). As for code mixing, the patient almost always responded in a different language from that of the examiner. Similarly, in their study of the language behaviour of two late bilinguals (German-Swedish and Swedish-Finnish) with AD, Hyltenstam & Stroud (1989) reported that both patients showed a tendency to use the language that was not shared by their Swedish-speaking addressees. Moreover, the patients' productions showed numerous intrusions of one language, reflecting the difficulty of keeping their languages separate. Finally, the nature of the elicitation task appeared to have an effect on the patients' choice



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of language. For instance, they preferred their L1 to recall distant memories. Although the patients' pragmatic difficulties were particularly marked in the severe stage of the disease, they depended on a variety of factors, including the age of acquisition of the languages involved, the premorbid degree of proficiency achieved for each of them, and/or the language(s) spoken in the environment. Similar observations were reported by De Santi, Obler, et al. (1990) and Obler et al. (1995). Results of the latter study, which included four English-Yiddish bilingual patients, only one of whom was an early bilingual, indicated that with the exception of the early bilingual, all the patients had difficulty addressing their interlocutor in the appropriate language. This difficulty increased with the severity of the disease, with both languages being impaired to the same extent in the most severely affected patient. Sometimes, the two languages were so jumbled up that it was impossible to tell which language was being spoken (De Santi et al., 1990). When Hyltenstam & Stroud (1993) and Hyltenstam (1995) studied two patients with mild AD, two with moderate AD, and two with severe AD—all late bilinguals with L1 Finnish and L2 Swedish—they found that the majority of participants (four out of six) often mixed languages, despite the strictly monolingual character of the experimental conditions. There was a clear trend for patients to use their L1 in the situation where L2 use was expected. In a longitudinal study conducted with three late bilingual (German-Dutch) patients with AD, Luderus (1995) investigated the directionality (p. 144) of intrusions (L1 to L2 versus L2 to L1) in the context of a conversation experimentally defined as strictly monolingual. Overall, their findings highlighted considerable variability in patients' conversational profiles and, consequently, the nature and extent of code mixing. The problems of language choice and language separation were shown to be strongly predicted by the balance of bilingualism in the premorbid period. The longitudinal approach made it possible to demonstrate that when bilingualism was balanced, the problems of language selection/separation appeared later on in the course of the disease. For patients with dominant bilingualism, these problems appeared earlier, and also had a predetermined directionality, depending on the premorbid dominance of L1 or L2. Likewise, Mendez et al. (1999) showed that bilingual patients with AD produce significantly more L1 intrusions in a later learned L2. Language choice and separation in bilinguals rely on the ability to take account of the specificity of the communication situation in order to inhibit the non-relevant language. The causes of separation and code mixing problems should therefore be sought primarily in executive functioning deficits. Moreover, the processes involved in bilingual language production are based on a network of connections between the prefrontal cortex, anterior cingulate cortex, inferior parietal region, and basal ganglia (Abutalebi & Green, 2007). Solving conflicts in language selection normally requires the intervention of specialized structures, namely the dorsolateral prefrontal cortex and anterior cingulate gyrus. Conflict arises in the inferior parietal cortex, but spreads to linguistic areas in the inferior frontal cortex. All these cortical structures are connected through subcortical structures to the basal ganglia, in particular the caudate nucleus, which is responsible for conflict resolution. Given that AD gradually affects (among other things) frontal and cingulate regions, as well as the subcortical nuclei, we can assume that bilingual patients increasingly encounter between-language competition and conflict resolution difficulties (i.e., inhibition of the non-target language). The term *inhibition* is used to describe a cog-

nitive control mechanism that tunes out the language that is irrelevant to the communicative context at hand (Abutalebi & Green, 2007; Costa & Sebastián-Gallés, 2014). In bilingual conversations, it prevents the speaker from producing utterances in the undesired language by keeping the irrelevant language below the selection threshold. The monitoring process that determines whether cognitive control mechanisms need to be applied to keep speaking in one language (i.e., activation) or switch to the other one (i.e., inhibition) is supported by the executive control system. Neuroimaging studies have shown that bilingualism affects the brain structures involved in the executive control system (e.g., greater density of grey matter in bilinguals' anterior cingulate cortex). The logical outcome of a cortical impairment affecting the neural basis of executive control (i.e., frontal and cingulate regions) is therefore language choice difficulties. The study of how bilingualism affects the neural basis of executive control processes has only recently commenced, and research on language changes in patients with AD is a promising avenue for extending current understanding of language control in bilingual speakers. It remains unclear whether code mixing/switching behaviours in bilingual patients with AD are due to a deficit in inhibitory control or to language loss (i.e., language attrition/regression). For the time being, the variety of experimental paradigms, the heterogeneity of patients' medical and linguistic profiles, the limited number of observations, and the inter-individual variability mean that it is still difficult to assess the impact of AD per se.

### (p. 145) 13.4 Conclusion

As underlined in Stilwell et al.'s recent review (2015), studies of language change in bilingual patients with AD are relatively inconclusive regarding the differential effects of AD on the two languages. Although they are not very informative regarding the order of L1 versus L2 deterioration in the course of the disease, these studies nonetheless raise important theoretical and methodological questions about how to test the multifaceted nature of bilingualism. For example, further research is needed to verify whether richer connections between concepts and words—which are characteristic of the dominant language—should be regarded as a strength or a weakness in the context of neurodegenerative diseases and attrition. Likewise, the issue of how to determine participants' dominant language, which surprisingly was never experimentally assessed in the above-mentioned studies, should be carefully taken into consideration when testing bilingual patients with AD, as it is a crucial dimension for understanding the direction of language decline. Previous discrepant results may have stemmed from the fact that patients' first-acquired language was not necessarily their dominant language (often the case in the context of migration). Furthermore, it is still unclear whether pathological ageing reverses language attrition as postulated by the reversion hypothesis put forward by de Bot & Clyne in 1989.

#### Notes:

\* The authors contributed equally to this work and the order of authorship is alphabetical.

## Linguistic Regression in Bilingual Patients with Alzheimer's Disease

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Melissa Barkat-Defradas received her PhD in Language Sciences in 2000 at University of Lyon and received the Young Researcher Award for her work. After a research fellowship at UC Berkeley she integrated the French National Centre for Scientific Research. She is now full-time researcher at The Institute of Evolutionary Sciences of Montpellier (France), where she develops interdisciplinary works that contribute to bridge the gap between linguistics and evolutionary biology. Her recent researches focus on psycholinguistic aspects of language processing in bilingual subjects suffering from Alzheimer's disease. She is currently interested in the determination of biological and environmental factors that may explain senescence in humans.

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Frédérique Gayraud is Professor of Psycholinguistics at Lyon University. Her main research interests include early language acquisition and language decline in Alzheimer's disease in a lifespan perspective. More specifically, the goal is to compare acquisition and desacquisition processes in order to test the retrogenesis hypothesis according to which degenerative mechanism reverse the order of acquisition in normal development. Another research interest focuses on bilingualism in normal and pathological ageing.

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Barbara Köpke is Professor of Neuropsycholinguistics at the University of Toulouse and head of the Octogone-Lordat Laboratory. Her research involves neuro- and psycholinguistic aspects of language processing in bilingual subjects with specific attention to 'extreme' situations such as L1 attrition, simultaneous interpreting, and aphasia. Her work has appeared in journals such as *Linguistic Approaches to Bilingualism* and *International Journal of Bilingualism*, and she is the editor of a special issue of *Journal of Neurolinguistics* on first language attrition.

### **Laurent Lefebvre**

Laurent Lefebvre has acquired an expertise in the study of language and executive functioning deficits encountered by patients with neurodegenerative diseases (Alzheimer's disease, Primary Progressive Aphasia, Vascular Dementia). He is at the head of the UMONS department of Cognitive Psychology and Neuropsychology since 2012. He created some neuropsychological tests (e.g. GREMOTS, DTLA) and cognitive interventions (e.g. Logaatome) specifically dedicated for aged patients with cognitive deficits. Laurent Lefebvre is a member of several scientific and patients' groups committees in neuropsychology and dementia. He is Full Professor at the University of Mons and Dean of the Faculty of Psychology and Education.