Memory and Language:
Insights from Picture Description and Past Tense Generation in a Native and a Second Language in Bilingual Alzheimer and Parkinson Patients.

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Abstract

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Despite the fact that bilingualism is common, little is known about the effect of aging or age-related disorders on bilingual speech production. No previous study has contrasted narratives or examined verb inflection in a native (L1) versus a second language (L2) in healthy older adults or patients. We tested 16 young and 16 older adults, and 9 Alzheimer (AD) and 8 Parkinson patients (PD), all French/English bilingual who learned L2 after age 8. Participants described a complex picture (Manuscript 1) and generated the past tense of verbs (Manuscript 2) in L1 and L2. The neurolinguistic models of Paradis (1994) and Ullman (2001) suggest that L2 grammar (when L2 is learned late) and the lexicon are linked to declarative memory, whereas L1 grammar is linked to procedural memory. Given that AD affects mostly declarative memory, and PD procedural memory, AD was expected to chiefly affect the lexicon in L1 and L2, and L2 grammar, and PD to mostly impact L1 grammar. The speech and verb inflection performance of AD patients suggests that AD affects lexical processing more than grammatical processing in L1, and affects L1 more than L2. The speech and verb inflection performance of PD patients suggest greater grammatical than lexical impairment in L1, but both grammatical and lexical difficulties in L2. The L1 findings replicate those in the literature. The L1-L2 findings suggest that AD and PD affect L1 and L2 differently, in a manner that differs from that predicted, and that aging has little effect on picture description and verb inflection.

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Memory and Language: Insights from Picture Description and Past Tense Production in a Native and Second Language in Bilingual Alzheimer and Parkinson Patients

This thesis examines memory and language in bilingual Alzheimer (AD) and Parkinson (PD) patients, in the context of the neurolinguistic models of Paradis (1994, 2004) and Ullman (2001, 2004). Briefly, the models posit that for a second language (L2) learned late, the lexicon and L2 grammar are dependent upon the declarative memory system, whereas grammar in a native language (L1) is dependent upon the procedural memory system. As reviewed in Gabrieli (1998), AD impairs primarily declarative memory, and PD primarily procedural memory. Based on this, the neurolinguistic models of Paradis (1994, 2004) and Ullman (2004) predict a double dissociation with AD patients showing greater impairments on measures of the lexicon and L2 grammar, and PD patients displaying greater difficulty on measures of L1 grammar. Two studies were conducted to test these predictions by comparing the L1 and L2 performance of bilingual AD and PD patients, relative to that of healthy controls, on a picture description task and a past tense generation task. The contribution of aging was investigated by contrasting the L1 and L2 performance of the healthy older controls to that of a group of healthy young bilinguals.

In the sections that follow, the declarative and procedural model of the lexicon and grammar (Paradis, 1994, 2004; Ullman, 2001, 2004) is discussed, following a brief introduction to bilingual neurolinguistics. Empirical support for the model is discussed, that includes a literature review on language in AD and PD. Last is an overview of the two thesis manuscripts, which contrast the effect of AD and PD on L1 and L2, and test whether the neurolinguistic models of Paradis and Ullman can help elucidate the process of language deterioration in bilingual AD and PD patients.

Introduction to Bilingual Neurolinguistics

Fabbro (1999) states that the most ancient document reporting language loss following brain disease is a 1700 BC Egyptian papyrus. Yet, it is only in the second half of the 19^{th} century that significant advances were made in the understanding of the cerebral organization of language. According to Fabbro (1999), it is based on the observation of the symptoms of a patient named Leborgne, and on that patient's brain autopsy, in Paris in 1861, that Pierre Paul Broca hypothesized that the faculty of articulated language was localized in the third convolution of the frontal lobe. Additional autopsies of the brain of patients who had lost the ability to speak confirmed Broca's hypothesis and led him in addition to state in 1865 that "we speak with our left hemisphere" (Broca, 1865; cited in Fabbro, 1999). In 1894, Carl Wernicke, a German neurologist, published a monograph describing hypotheses about cerebral organization and reported on two cases of "sensory aphasia" (Wernicke, 1894; cited in Fabbro, 1999). Now known as "Wernicke's aphasia", the syndrome is defined as an inability to comprehend speech or to produce meaningful speech, following lesions to the posterior portion of the superior temporal gyrus (e.g., Kolb & Wishaw, 1990).

These discoveries on the brain organization of language ignited the question of how multiple languages are represented in the brain. The simplest hypothesis was that if multiple languages were represented together in the same brain area, then brain damage should affect each language of a bilingual or polyglot equally. Numerous case studies between 1843 and 1982, translated in Paradis (1983), did not support this hypothesis, and recent estimates reported in Fabbro (1999) suggest that whereas about 40% of bilinguals exhibit parallel recovery of all languages after brain insult, approximately 32% and 28% display better recovery of L1 and L2, respectively. These observations yield two very interesting questions: First, why are there differential impairments and recovery of languages mastered equally before brain injury (i.e., are languages represented differently in the brain, are they processed differently, etc)? Second, what determines, in the case of selective impairment or recovery, which language is impaired or recovered? Several explanations, some of which are reviewed in Paradis (2004), have been proposed since the late 1800s but none has been able to accommodate all observations. Failure to develop a theory that could usefully predict L1 and L2 impairment in different linguistic domains (i.e., phonology, morphology, syntax, lexicon, and pragmatics), following brain injury or degeneration, may be partly due to the fact that historically, language has been studied as an entity. Inasmuch as language shares underlying brain circuitry with other cognitive or even motor functions, examining language uniquely in isolation from other cognitive faculties may prevent, limit, or delay, the uncovering of the rules that govern L1 and L2 acquisition, maintenance, and attrition.

An excellent candidate to help elucidate the relationship between brain and language is memory. Ribot was one of the first to write on the possible link between memory and language in "Les maladies de la mémoire" (1881: translation in Paradis, 1983). He proposed that the earlier a language is learned, the more immune it is to brain injury, just as earlier memories are usually better spared by brain insult. Relative to research on memory or on language, there have been few attempts at specifying the role of memory in acquiring and sustaining single or multiple languages since Ribot. There have been publications on the role of implicit and explicit processes in second language acquisition, but these contrast the role of implicit strategies (i.e., practice) and explicit techniques (i.e., the learning of rules) in L2 acquisition (e.g., Levin, 1969). Their goal was not to specifically relate language components in L1 and L2 to the implicit and explicit memory systems of Cohen and Squire (1980). Paradis (1994) was the first to postulate precise links between memory and language in bilinguals in his "neurolinguistic model of metalinguistic knowledge and implicit linguistic competence". Ullman (2001) then developed his "declarative-procedural model of the lexicon and grammar", which is fundamentally complementary to Paradis's model. These are reviewed next.

The Declarative-Procedural Model of the Lexicon and Grammar

Declarative and Procedural Memory: Memory is not a unitary construct. Dissociations in the performance of patients with different brain injury, as well as dissociations in the performance of healthy participants under certain experimental conditions, have prompted the proposal of various taxonomies (see Haberlandt, 1999). One of the most influential taxonomies is Larry Squire's declarative and procedural memory (Haberlandt, 1999). Declarative memory refers to the ability to tell about what one knows. It is highly flexible, in that it integrates new information from various modalities (e.g., bird-related knowledge can easily be expanded by reading from appropriate sources and bird-watching). Converging evidence from lesion studies and functional neuroimaging studies (reviewed in Gabrieli, 1998) suggests that regions of mesial temporal lobe that include the hippocampus, entorhinal cortex, parahippocampal cortex, but not the amygdala, subserve declarative memory. By contrast, procedural memory refers to memory for certain ways of doing things or for certain movements, independent from memory used to "tell about" the ability. Procedural memory is inflexible, in that new information or new procedures cannot easily be incorporated into an internalized procedure. For instance, after singing an aria with a flat repeatedly, it can be difficult to substitute a sharp for the flat while singing, despite clear knowledge of the required change. Procedural memory is hyper-specific. Procedural knowledge cannot be incorporated into a knowledge base, such that for instance, one can type but not be able to tell where specific keys are on the keyboard. It also cannot be integrated into another procedure, as for example, knowing how to type does not make one know how to play the piano, or knowing Spanish as an L2 does not help know Chinese as an L3. Based on Gabrieli (1998)'s review of human memory, subcortical structures, the basal ganglia in particular, as well as the striatal-thalamic-cortical pathway, are involved in skill learning and maintenance. The dissociation between declarative and procedural memory has received considerable support, especially from anterograde amnesics who are able to learn new skills but not new facts. Milner's patient H. M. became amnesic after temporal lobe surgery that involved hippocampal removal. In the 40 years that followed, H. M. would benefit from practice on tasks such as mirror drawing, mirror reading, or recognizing objects from fragmented pictures, despite remaining incapable of learning new words or the names of familiar people (Cohen, 1991; cited in Paradis, 1994).

Paradis (1994, 1997, 1998a, 1998b) made explicit the link between declarative memory and "metalinguistic knowledge", and that between procedural memory and "implicit linguistic competence". Ullman (2001) further elaborated on the nature of these associations and proposed the term "memorized mental lexicon" to refer to Paradis' "metalinguistic knowledge", and the label "computational grammar" to refer to Paradis' "implicit linguistic competence". The parallels drawn by Paradis (1994) and Ullman (2001) between specific memory systems (declarative/procedural) and language components have important implications for our understanding of the processing of lexical items and grammar within a language, and across languages in bilinguals and polyglots. These are defined and reviewed next.

Declarative Memory and Metalinguistic Knowledge/Lexicon: According to Paradis (1994, 1997, 1998a, 1998b), metalinguistic knowledge (knowing "that") is learned consciously, is available for conscious recall, and is applied to the comprehension and production of language in a controlled manner. Metalinguistic knowledge relies on declarative memory, which depends on the integrity of the hippocampal system and is stored diffusely over large areas of tertiary cortex. Ullman (2001, 2004) refers to aspects of language to which these characteristics apply as the "memorized mental lexicon", and remarks on the functional similarities between declarative memory and the lexicon. For instance, declarative memory allows for associations to be formed rapidly, just as learning a new word involves the binding of the phonological input (sound of the word) to the object or concept it refers to or is associated with. According to Ullman (2001), the mental lexicon contains memorized words (i.e., pairings of sound and meaning), bound morphemes (e.g., "*inter*nation*al*") and idiomatic phrases (e.g., "To go out on a limb"). Ullman (2001) was the first to explicitly posit a correspondence among lexical items, facts, and events, with regards to their representations and processing.

Procedural Memory and Implicit Linguistic Competence/Grammar: According to Paradis (1994, 1997, 1998a, 1998b), implicit linguistic competence (knowing "how to") is acquired incidentally, is stored in the form of procedural know-how, without conscious knowledge of its contents, and is used automatically. Implicit linguistic competence is thought to rely on procedural memory, which is mediated by subcortical structures, mainly the basal ganglia and cerebellum. Ullman (2001) refers to aspects of language to which these characteristics apply as the "computational mental grammar". According to Ullman, the grammar contains rules, including operations and constraints, which underlie the productive combination of lexical forms into complex structures such as sentences, or words. An example of a grammatical computation is the generation of the past tense of regular verbs by adding the suffix "ed" to a verb stem (e.g., "walk" + "ed" = "walked"). Ullman (2001) was the first to explicitly posit a correspondance among grammar, skills, and habits, with regards to their representations and processing.

Implications of these Parallels for the Processing of L1 and L2: As Fabbro (1999) explains, comprehension in L1 presupposes the concurrent activation of declarative memory, which is responsible for lexical recognition, and of procedural memory, which is responsible for grammatical comprehension. Similarly, L1 language production requires the retrieval of lexical items from declarative memory, and the synchronized implementation of the computational and sequencing operations of grammar, based on procedural memory. The extent to which an L2 recruits declarative and procedural memory in the same manner as an L1 does is posited by Paradis (1997) to depend on at least three factors. These are the age at which L2 was acquired, the degree of mastery of L2, likely a function of practice in communicative situations, and the degree of motivation in acquiring L2. According to Paradis (1997), a later age of acquisition, low degree of mastery of L2, and limited practice of L2 in a conversational situation where the motivation is to communicate, are all associated with decreased implicit linguistic competence in L2, and by consequence, by an increased reliance on metalinguistic knowledge and pragmatics in the comprehension and production of L2. Reliance on declarative memory should be greatest, and reliance on procedural memory smallest, under these conditions. In a similar vein, Ullman (2001) suggests that later exposure to language can impair the ability of the procedural memory system to learn or compute aspects of grammar. As a result, forms that may be computed grammatically in L1 (e.g., generating the past tense of "talk" by implementing the "talk" + "ed" procedure) may depend on lexical or declarative memory in L2 (e.g., retrieving "talked" as an entity). As such, productivity in L2 emerges from the ability to form associations and remember them, whereas production in L1 emanates from the on-line implementation of rules. The fact that there may be a critical period for language acquisition, after which grammar in particular is negatively affected (see DeKeyser & Larson-Hall, 2005) is consistent with the position of Paradis (1994, 2004) and Ullman (2001, 2004) that L1 and L2 grammar are distinct and likely sustained by different brain mechanisms when L2 is learned late. Evidence for the declarative-procedural model of the lexicon and grammar comes from many sources and it is extensively reviewed in Ullman (2004). Evidence from neuroimaging, Event-Related Brain Potentials (ERPs), and aphasia, in monolinguals and bilinguals, is summarized briefly next, followed by a review of the evidence from the pattern of language impairment in AD and PD.

Evidence for the Declarative-Procedural Model of the Lexicon and Grammar

Evidence from Healthy Populations: Functional neuroimaging and event-related brain potentials (ERPs) provide insight into brain-language relations. These techniques can be used with healthy participants, and tell how a cognitive function can work. This information nicely complements that from patient observations which show how a cognitive function can fail. In monolinguals, several studies have documented activation in temporal and temporo-parietal regions during the processing of semantic and lexical information (Damasio, Grabowski, Tranel, Hichwas, & Damasio, 1996; Martin et al., 2000; Newman, Pancheva, Ozawa, Neville, & Ullman, 2001). Conversely, many studies have reported activation in the ventro-lateral pre-frontal cortex, and Broca's area in particular, during procedural memory tasks and tasks of syntactic processing (Caplan, Alpert, & Waters, 1998; Embick, Marantz, Miyashita, O'Neil, & Sakai, 2000; Indefrey, Hagoort, Herzog, Seitz, & Brown, 2001; Moro, Tettamanti, Perani, Donati, Cappa, & Fazio, 2001). These observations are as expected if the lexicon is associated with declarative memory and temporal lobe functions, and if grammar is associated with procedural memory and its neural substrate.

In bilinguals, several neuroimaging studies have investigated single word processing and found no consistent difference in activation patterns between L1 and L2 (Chee, Tan, & Thiel, 1999; Klein, Milner, Zatorre, Meyer, & Evans, 1995; Klein, Milner, Zatorre, Zhao, & Nikelski, 1999; Klein, Zatorre, Milner, Meyers, & Evans, 1994, 1995). These results are consistent with the position that the lexicon is dependent upon declarative memory, irrespective of whether an L1 or an L2 is at issue. By contrast, neuroimaging studies that have examined sentence processing have observed differences in activation patterns between L1 and L2. Dehaene et al. (1997) tested French-English bilinguals, who learned their L2 after age seven. The participants listened to stories in L1 and L2 and exhibited greater dispersion in temporal lobe activation in L2 than in L1, as measured with fMRI. This evidence is interpreted by Ullman (2001) as evidence for greater reliance on temporal lobe structures in L2 than in L1. Perani et al. (1998) tested Italian-English bilinguals, who had learned L2 after age 10 (these were referred to as "late bilinguals"), and Catalan-Spanish bilinguals, who had been exposed to L2 after age 2 but learned it before age 10 (these were referred to as "early bilinguals"). Participants listened to stories in L1 and in L2, as their brain activation was measured with PET. Perani et al. (1998) found greater bilateral temporal activation in L2, even in the "early bilinguals". Ullman (2001) interprets these findings as further support for the greater involvement of temporal lobe structures in the processing of L2, relative to L1.

Whereas neuroimaging techniques offer superior spatial resolution, ERPs provide finer temporal resolution. As such, information from fMRI/PET and ERP studies complements each other. Weber-Fox and Neville (1996) tested Chinese-English bilinguals using a syntactic and lexical-semantic violation ERP paradigm. The participants varied on age of exposure to English. The behavioral measures indicated that lexical-semantic processing was relatively impervious to age of exposure to L2, but that syntactic processing was not. This finding was also observed in the ERP data. The N400 ERP component, elicited by semantic violations, was not affected by language (L1/L2). The late anterior negativity (LAN) ERP component, which is elicited automatically in response to syntactic violations, differed in amplitude and scalp distribution between the English-L1 controls and the English-L2 participants. However, the P600 ERP component, which has also been associated with syntactic integration, was not affected by language (L1/L2). Hahne and Friederici (2001; cited in Ullman 2001) used a comparable design and observed disruption of both the LAN and P600 ERP component, in the context of an intact N400 response. In sum, the two ERP studies reviewed suggest that L1 and L2 differ at the level of the grammar and not of the lexicon, as predicted by Ullman's declarative-procedural model of the lexicon and grammar (2001).

Evidence from Aphasics: There are two major types of aphasia: non-fluent or Broca's aphasia, and fluent or Wernicke's aphasia, as discussed in the introduction to the bilingual neurolinguistics section of this thesis. Fluent aphasia is associated with impairment in the understanding and production of content words, with relative preservation of syntax, and is observed after damage to the left temporal and temporo-parietal regions, based on evidence reviewed in Damasio (1992) and Goodglass (1993). Non-fluent aphasia, sometimes associated with agrammatic speech, is associated with lesions of left ventro-lateral frontal regions, especially Broca's area, as well as the basal ganglia, although portions of inferior parietal cortex and anterior superior temporal cortex have also been implicated in studies reviewed in Damasio (1992) and Goodglass (1993). It would thus seem that fluent aphasia is associated mostly with impaired lexical processing and with damage to structures that are part of the declarative memory system (i.e., temporal and temporo-parietal regions), whereas non-fluent aphasia is associated predominantly with impaired grammatical processing and is observed following damage to structures comprised in the procedural memory system (e.g., basal ganglia).

The bilingual aphasia literature is extensive, but unfortunately, the description of lesion sites and language characteristics is often limited. As Paradis (1995) states, a robust finding from the aphasia literature, confirmed with neuroimaging, is that the left hemisphere is dominant for language for L2, just as it is for L1. Nevertheless, there is evidence that the left temporal lobe structures may be more important for L2 processing than L1. For instance, Ku, Lachmann, and Nagler (1996), describe the case of a Chinese teenager living in the United States for six years. After the onset of herpes simplex encephalitis involving the left temporal lobe, he lost the ability to understand or speak English but not Chinese. There is also evidence that lesions of the left basal ganglia result in greater impairment of L1 grammar than of L2 grammar. Fabbro and Paradis (1995) report on four such cases.

Evidence from Speech in AD and PD: AD initially affects the hippocampus, entorhinal cortex, and later the association cortices (Hyman, Van Hoesen, Damasio, & Barnes, 1984). These regions sustain declarative memory, and declarative memory impairment is a hallmark of AD, according to Gabrieli (1998). AD spares, at least at the outset, subcortical areas of the frontal lobes including the basal ganglia and, as expected, aspects of procedural memory are relatively spared in AD based on evidence reviewed in Gabrieli (1998). If declarative memory sustains metalinguistic knowledge or the lexicon, and not implicit linguistic competence or grammar, AD patients should display lexical deficits in the context of relatively intact grammatical processing.

By contrast, PD is characterized by the loss of dopamine in the basal ganglia and associated brain region such as the caudate nucleus (McDowell, Lee, & Sweet, 1978). These regions sustain procedural memory, and as expected, procedural memory has been shown to be impaired in PD in studies reviewed in Gabrieli (1998). Idiopathic PD spares the hippocampus, entorhinal cortex, and temporo-parietal cortex, and as predicted, spares declarative memory, based on evidence cited in Gabrieli (1998). If procedural memory sustains implicit linguistic competence or grammar, and not metalinguistic knowledge or the lexicon, PD patients should display grammatical deficits in the context of relatively intact lexical processing. The literature on language in AD and PD indicates that, as predicted, AD patients are impaired on lexical processes, such as naming and word fluency, but show relatively intact performance on tests of grammatical comprehension and production. As expected based on the declarative-procedural model of the lexicon and grammar, PD patients show the opposite pattern of language performance. They are impaired on measures of syntactic comprehension and production, but perform well on lexical measures. The evidence is reviewed below, for AD and PD patients, for the lexicon and grammar.

The Lexicon: Lexical abilities are often tested using naming tasks and fluency tasks. AD patients have been consistently found to make more errors than do healthy older adults on naming tasks, such as confrontation naming on the Boston Naming Test (Bayles, Tomoeda, & Trosset, 1992; Hodges, Salmon & Butters, 1992), especially for low frequency words (Skelton-Robinson & Jones, 1984). The nature and meaning of lexical errors is not entirely understood, and Nicholas, Obler, Au, and Albert (1996) showed that the errors of AD patients are as semantically related to the target names as those of healthy controls. Some intriguing observations are also reported in the literature. For instance, Irigaray (1967) found naming in AD to be most impaired for nouns, and least impaired for verbs, with adjectives being intermediately impaired. Hart (1988) found that naming proficiency increased when AD patients were able to handle objects, and Emery (1996) noted that AD patients have more difficulty naming drawings of objects than naming the objects themselves. Verbal fluency has been found to be even more severely impaired than confrontation naming in AD, and the impairments in verbal fluency can be detected earlier than those in naming (Bayles & Kaszniak, 1987; Emery, 1985, 1988, 1993, 1996; Kertesz, 1994). Non-demented PD patients, by contrast, appear to exhibit intact naming ability and letter fluency (e.g., Lewis, Lapointe, Murdoch, & Chenery, 1998; Pirozzolo, Hansch, Mortimer, Webster, & Kuskowski, 1982). The literature on naming and word fluency in AD and PD indicates that AD, but not PD, strongly affects lexical processing. This observation is consistent with the proposal that lexical processing is associated with declarative memory and its neural substrate, and not with procedural memory and its cerebral substrate.

Grammar: While there is general agreement that the lexicon is affected by AD, there is weaker consensus regarding the status of grammar in AD. Syntactic processing has been found to be relatively well preserved in AD by some researchers (Kempler, Curtiss, & Jackson, 1987), but impaired by others (see Emery, 1996). Recent evidence suggests that the syntactic difficulties in AD may be due to limited processing capacity, that is from working memory deficits, rather than to interference with syntactic functions per se, since the performance of AD patients on tests of syntactic comprehension is affected by the number of propositions but not by the syntactic complexity of the sentences (Grossman & White-Devine, 1998; Small, Kemper, & Lyons, 2000; Waters, Caplan, & Rochon, 1995; Waters, Rochon, & Caplan, 1998). Finally, there is the effect of progression of the disease, such that grammatical impairments may not be evident early on, but become apparent in the later stages of AD. For instance, Emery (1985) administered The Chomsky Test of Syntax to AD patients. An example of an item on the Chomsky Test of Syntax is as follows: the subject is presented with a blindfolded doll and asked if the doll is easy to see or hard to see. Eleven of the 20 AD patients that Emery tested said that the doll was hard to see because of the bandana around her eyes. These 11 patients were the ones in the moderate or severe stages of AD. Taken together, the evidence would suggest that grammar is spared in the early stages of AD, unless the complexity of the sentences place heavy demands on working memory, but that the disease affects grammatical abilities in later stages.

PD patients, by contrast, have consistently been shown to exhibit grammatical impairments (Geyer & Grossman, 1994; Grossman et al., 1993; Grossman, Carvell, Gollomp, Stern, Vernon & Hurtig, 1991; Grossman, Carvell, & Peltzer, 1993; Grossman, Carvell, Stern, Gollomp, & Hurtig, 1992; Grossman, Crino, Reivich, Stern, & Hurtig, 1992; Kemmerer, 1999; Lieberman, Friedman, and Feldman, 1990; McNamara, Krueger, O'Quin, Clark, & Durso, 1996; Natsopoulos, Katsarou, Bostanzopoulos, Grouios, Mentenopoulos, & Logothetis, 1991; see Grossman, 1999 for a review). Lieberman, Friedman, and Feldman (1990), and Natsopoulos, Katsarou et al. (1991), asked PD patients to match sentences containing relative clauses to pictures. The sentences were designed such that there were no semantic or pragmatic constraints to support sentence interpretation, but instead required patients to decode the grammatical phrase structure of the sentence. PD patients were impaired on this task. In Grossman et al. (1991), PD patients were shown to benefit from semantic constraints in their interpretation of sentences, regardless of the sentences' grammatical structure, thereby showing that the deficits in decoding grammar occur in the context of intact semantic processing, as would be predicted from the declarative-procedural model of the lexicon and grammar.

<u>The Lexicon and Grammar in Discourse</u>: The same performance dissociation as that observed for single word production and sentence comprehension, with AD patients displaying clear lexical limitations but relatively spared grammar, and PD patients showing grammatical impairments in the context of intact lexical processing, is observed

in free speech. In discourse production, the free speech of AD patients has been compared to that of Wernicke aphasics (Chapman, Highley, & Thompson, 1998; Mathews, Obler, & Albert, 1994). It is characterized by a high proportion of words and utterances that convey little or no information, by closed-class phrases, ill-defined pronouns, and interruptions (Almor, Kempler, MacDonald, Andersen, & Tyler, 1999; Cummings, Darkins, Mendez, Hill, & Benson, 1988; Hier, Hagenlocker, & Shindler, 1985; Illes, 1989; Nicholas et al., 1985). Bucks, Singh, Cuerden, & Wilcock (2000) conducted a Principal Component Analysis on data from the spontaneous speech of AD patients and identified two components: Word finding difficulty and poverty of word content, but adequate generation of adjectives, pronouns and verbs, and a good ability to construct sentences. In picture descriptions, AD patients show a decrease in information units or other measure of meaning, and less specific words used (Bschor, Kuhl, & Reischie, 2001; Croisile et al., 1996; Ehrlich, Obler, & Clark, 1997). AD patients display a reduction in the number of words used and the number of unique words (e.g., Hier et al., 1985). The speech of PD patients, by contrast, is marked by diminished grammatical complexity, as evidenced by decreased phrase length and fewer dependent clauses, by open-class phrases, and by impaired speech melody, abnormally long hesitations, and dysarthria (Cummings, Darkins, Mendez, Hill, & Benson, 1988; Illes, 1989; Illes, Metter, Hanson, & Iritani, 1988). Thus overall, AD patients show decrements in lexical processing and PD patients in grammatical processing.

<u>The Lexicon and Grammar in Verb Inflection</u>: The Past Tense Generation task (PTG) requires the subject to generate the past tense of irregular and regular verbs that are embedded in meaningful sentences, and permits the concurrent evaluation of lexical and

grammatical abilities. Based on the dual-system model of verb inflection (see Pinker, 1999), the past tense of regular verbs in L1 is generated productively by adding "ed" to the verb stem (e.g., "walk" + "ed" = "walked"). By contrast, the past tense of irregular verbs (e.g., "taught") must be retrieved from declarative memory since it cannot be derived from the stem (e.g., "teach"). In sum, the dual-system model posits that generating the past tense of irregular verbs is a lexical function, whereas generating the past tense of regular verbs in L1 is a grammatical function. The performance of healthy and patient populations on the PTG has provided evidence for the dual-system model of verb inflection. For instance, it has been empirically demonstrated that the past tense of frequent irregulars is generated faster than that of less frequent irregulars, as expected if these are retrieved from declarative memory, whereas frequency has no effect on the latency to generate the past tense of regular verbs, as expected if these are generated productively (see Pinker, 1999; Ullman, 1999).

The PTG has been implemented in many languages including French (e.g., Rose & Royle, 1999), English (Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz, & Pinker, 1997), German (e.g., Marcus, Brinkmann, Clahsen, Wiese, & Pinker, 1995), and Italian (e.g., Orsolini, Fanari, & Bowles, 1998). It has been used to study a variety of language disorders such as specific language impairment (e.g., Ullman & Gopnik, 1999). The PTG is well controlled in that the stimuli used to test lexical and grammatical abilities can be matched on complexity (i.e., one word), syntax (i.e., tensed), and meaning (i.e., past). The demand on short-term memory can be matched by making the sentences that embed the verbs the same length and complexity. These features of the PTG make it ideal to compare the performance of patient populations that differ in their cognitive impairment, such as AD and PD. Ullman et al. (1997) had 24 AD and 28 PD participants generate the past tense of regular verbs, irregular verbs, and pseudo-verbs. As predicted based on the dual-system model of verb tense inflection and on the selective memory deficits of the two patient groups, the AD patients (the five most anomic ones) made more errors producing the past tense of irregular than regular verbs and pseudo-verbs, whereas the PD patients (the five most hypokinetic ones) made more errors producing the past tense of regular verbs and pseudo-verbs than irregular verbs. Ullman et al. (1997) illustrate the dissociation in the performance of AD and PD patients on lexical and grammatical processing, as predicted from Ullman's model (2001), within a single study.

Bilingual AD and PD: Only eight studies have examined how AD affects L1 and L2 (De Vreese, Motta, & Toschi, 1988; Dronkers, Koss, Friedland, & Wertz, 1986, cited in Hyltenstam & Stroud, 1993; Friedland & Miller, 1999; Hyltenstam & Stroud, 1989, 1993; De Picciotto & Friedland, 2001; De Santi, Obler, Sabo-Abramson, & Goldberger, 1989; Meguro et al., 2003), and one has investigated how PD affects language in bilinguals (Zanini et al., 2004). Studies on bilingual AD have shown that AD patients may display better word fluency in L1 than in L2 (De Piciotto & Friedland, 2001), and that generally, they code-switch into L1 more than into L2 (Hyltenstam & Stroud, 1989, 1993). These observations are consistent with the declarative-procedural model of the lexicon and grammar, in that they suggest that AD may have greater impact on L2 than on L1. Dronkers et al. (1986; cited in Hyltenstam & Stroud, 1993) report equal impairment in L1 and L2, whereas De Santi et al. (1989) report differential L1/L2 impairment across linguistic functions. De Vreese, Motta, and Toschi (1988) report on an AD patient who translated spontaneously into L2. The implications of these findings for the declarative-procedural model of the lexicon and grammar are not clear. Meguro et al. (2003) investigated language in four Japanese-Portuguese bilinguals, and report that they were more impaired for irregular words, defined as those for which there is not a one-to-one correspondance between written form and sound, in both Japanese and Portuguese. This observation is in accordance with the models of Paradis (1994) and Ullman (2001), as AD was shown to affect the processing of irregular words, which is assumed to depend on the declarative memory system, more than the processing of regular words, which is posited to rely on the procedural memory system. In PD, Zanini et al. (2004) demonstrated greater syntactic impairments in L1 relative to L2 using tests of sentence comprehension and syntactic judgment. The literature on bilingual AD and PD is narrow, but the studies reviewed seem generally in accordance with the position that AD affects L2 grammar more than L1 grammar, whereas PD affects L1 grammar more than L2 grammar, as predicted from the declarative-procedural model of the lexicon and grammar. A limitation of the literature on bilingual AD is the small sample sizes. Dronkers et al. (1986; cited in Hyltenstam & Stroud, 1993) and De Vreese et al. (1988) are case studies. Hyltenstam and Stroud (1989) report on language in two bilingual AD patients. De Santi et al. (1989), Friedland and Miller (1999), and Meguro et al. (2003) each tested four bilingual AD patients, whereas Hyltenstam & Stroud (1993) and De Piciotto & Friedland (2001) tested six. These studies examined various linguistic functions, such as fluency, code-switching, translation, but were not designed specifically to contrast lexical and grammatical functions in bilingual AD.

Thesis Research Overview

The goal of this thesis is to further our understanding of how language deteriorates in AD and PD based on how each disease affects the brain, and to determine whether this effect differs across language (L1/L2) and linguistic function (lexicon/grammar). Over the past 150 years, several hypotheses have been proposed to explain differential patterns of language impairments in bilingual aphasics, some of which are reviewed in Paradis (2004), such as better L1 or L2 recovery. Most have proven too simplistic and limited in their ability to explain case observations (e.g., the position that the language most used at the time of brain insult is best recovered). The declarative-procedural model of the lexicon and grammar is appealing because of its potential to explain and predict how brain insult or degeneration will affect language in bilinguals and polyglots. It has received support converging from different domains and methodologies, including neuroimaging, ERPs, aphasics, AD, PD, within a native and a second language. The declarative-procedural model of the lexicon and grammar was chosen to guide the hypotheses tested in this thesis research because it makes clear predictions for how AD and PD are expected to affect the lexicon and grammar in L1 and L2. Specifically, it predicts that AD will affect mostly the lexicon and L2 grammar, and that PD will affect predominantly L1 grammar. These predictions were tested using a picture description task (Manuscript One) and a past tense generation task (Manuscript Two).

The picture description task was chosen because it allows for a relatively naturalistic examination of speech, under conditions that minimize working memory demands. This was important because both AD and PD have been shown to affect working memory (e.g., Bublak, Muller, Gron, Reuter, & von Cramon, 2002). The picture description task has been relatively widely implemented with monolingual AD patients, and although the specific measures used have differed, the findings consistently document lexical difficulties and relatively intact grammar. One study examined picture description in PD and documented grammatical difficulties in the context of intact lexical ability (Murray, 2000). Picture description has never been examined in L2 in AD or PD.

The past tense generation task was selected because it allows for lexical and grammatical abilities to be tested as similarly as possible. In picture description, lexical measures are typically single word measures, whereas grammatical measures tend to be sentence level measures. By contrast, the past tense generation task yields lexical (i.e., generation of the past tense of irregular verbs) and grammatical measures (i.e., production of the past tense of regular verbs) that are matched on complexity (i.e., one word), syntax (i.e., tensed), and meaning (i.e., past). Thus, whereas the picture description task offers the advantage of being naturalistic, the past tense generation task provides well-matched lexical and grammatical measures, and while the picture description task allows the examination of single word, sentence, and discourse level measures, the past tense generation task allows the direct investigation of morphosyntax. The two tasks complement each other in many such ways, and are easy enough to perform for AD and PD populations. The past tense generation task has not been employed widely with patients, unlike the picture description task, but it has been used to assess the lexicon and grammar in AD and PD in a single experiment, which found AD patients to be most impaired in generating the past tense of irregular verbs and PD patients to be most impaired in generating the past tense of regular verbs (Ullman et al., 1997). The past tense generation task has never been administered to bilingual AD or PD patients.

In this research, the picture description task and the past tense generation task were administered to groups of young and older adults, and AD and PD patients, all French/English bilinguals who learned L2 after age 8. Relative to previous studies, the sample sizes for each group were larger. The participants met strict language criteria (e.g., currently using their L1 and L2 at least 30% of the time). Each patient was matched to a healthy participant who resembled the patient on demographic variables, such as age and years of education, for instance, as well as on linguistic variables, such as the age and method of L2 acquisition. Memory and language were assessed for each participant, who was administered declarative and procedural memory tests, in the verbal and visual modality, in his/her native language. This was done to document declarative memory deficits in the AD group and procedural memory impairments in the PD group. They then completed the picture description and past tense generation tasks in L1 and L2, with the two languages being tested on separate days. Manuscript One describes the performance of the four groups on the picture description task, and Manuscript Two describes their performance on the past tense generation task. Results from the two tasks are only partially in accordance with the declarative-procedural model of the lexicon and grammar. On the picture description tasks, the results are as expected in L1, in that AD affected mostly the lexicon and PD mostly grammar, but are not as predicted in L2, in that PD patients evidenced grammatical difficulties whereas AD patients did not. On the past tense generation task, the findings provide some support for AD affecting L2 to a greater extent than L1, and PD impacting L1 to a greater extent than L2.

Contributions of this Research

Most people speak more than one language, and age-related diseases are becoming prevalent. Understanding language deterioration in bilingual AD and PD has both theoretical and practical implications. Theoretically, it provides information on how the two languages of a bilingual may be represented and processed in the brain. In practice, it can guide interventions geared toward offering better care for patients. For instance, knowledge of whether L1 or L2 is most negatively impacted by AD can guide the choice of a care facility. The findings from this research indicate that AD and PD may differentially affect L1 and L2, in a manner that cannot be entirely explained by a model positing links between declarative memory and the lexicon and L2 grammar, and between procedural memory and L1 grammar. This study is the first to directly compare the lexicon and grammar in L1 and L2 in groups of bilingual AD and PD patients. Whereas the results do not yield a simple answer to the question of how language deteriorates in AD and PD based on the neuropathology of these diseases, it is hoped that this study will stimulate interest and further research into this intriguing and relatively new area.

Manuscript 1

Memory and Language:

Insights from Picture Description

in Bilingual Alzheimer and Parkinson Patients

Abstract

Despite half the world population being bilingual, little is known about the effect of aging or age-related disorders on bilingual speech production. No previous study has contrasted narratives in a native (L1) vs. a second language (L2) in healthy older adults or patients. We tested 16 young and 16 older adults, and 8 Alzheimer (AD) and 8 Parkinson patients (PD), all French/English bilinguals having learned L2 after age 8. Participants described the Cookie Theft Picture in L1 and L2 (Goodglass & Kaplan, 1983). The neurolinguistic models of Paradis (1994) and Ullman (2001) suggest that L2 grammar (when L2 is learned late) and the lexicon are closely linked to declarative memory, whereas L1 grammar is linked to procedural memory. Given that AD affects mostly declarative memory, and PD procedural memory, AD was expected to chiefly affect the lexicon in L1 and L2 and L2 grammar, and PD to mostly impact L1 grammar. As predicted, since aging generally spares procedural memory and the semantic aspects of declarative memory, aging had little effect on picture description, across languages. In L1, AD affected mostly the lexicon and PD mostly grammar: compared to their controls, AD patients produced more lexical errors, used more pronouns, and fewer unique words, but did not differ on any grammatical measures. PD patients made more grammatical errors than their controls, but did not differ on the lexical measures. By contrast, in L2, PD patients evidenced grammatical difficulties whereas the AD patients did not. Therefore, the results do not unambiguously support the neurolinguistic models of L1/L2 of Paradis (1994) and Ullman (2001), and suggest that AD may lead to greater lexical impairment in L1 and that PD may lead to grammatical impairments in L1 and L2.

Memory and Language:

Insights from Picture Description in Bilingual Alzheimer and Parkinson Patients

Bilingualism is a worldwide reality. Yet, knowledge about how two or more languages are represented or processed in the brain remains elusive, as does the role of memory systems, such as declarative and procedural memory, in supporting specific language functions, in a second as well as in a native language. Alzheimer's disease (AD) and Parkinson's disease (PD) each affect a specific neurofunctionally separable memory system (see Gabrieli, 1998, for a review). As such, the study of languages in bilingual AD and PD patients offers a unique insight into the relationship between memory and language, as well as into the neural underpinnings of language functions. This study examined the effect of aging, and of AD and of PD, on the free speech description of a complex picture in an L1 and L2. The aim was to determine whether AD and PD each affect specific language components in L1 and L2, as would be predicted from Paradis' neurolinguistic theory of bilingualism (1994, 2004) and Ullman's declarative/procedural model of the lexicon and grammar (2001), two compatible current theories of memory and language.

Memory is not unitary, and dissociations in the task performance of healthy and patient populations have encouraged the proposal of taxonomies. An influential taxonomy is that of declarative and procedural memory (Cohen & Squire, 1980; Cohen, 1984). Declarative memory refers to memory for facts and events which can be stated. It is flexible in that it integrates new information from various modalities. For instance, a person can expand his/her geography knowledge by reading on the topic or by traveling. Converging evidence from lesion and neuroimaging studies suggests that regions of mesial temporal lobe that include the hippocampus, entorhinal cortex, and parahippocampal cortex, sustain declarative memory (this evidence is reviewed in Gabrieli, 1998). By contrast, procedural memory refers to memory for procedures or movement sequences, independent from memory used to "tell about" the procedure or movement. Procedural knowledge is inferred from performance. A perfect example is typing. Most typists would not be able to easily or quickly tell where specific keys are located on the keyboard, yet the fact that they can type reflects knowledge, procedural knowledge, of where the keys are. Procedural memory is inflexible such that new information cannot easily be incorporated into information already available. For instance, the ability to type does not allow the typist to play the piano. Subcortical structures, especially the basal ganglia, play a role in the aquisition and maintenance of procedures. These regions project to areas of the frontal cortex through specific striatal-thalamic-cortical loops that sustain particular motor, perceptual, and cognitive skills, as described in Gabrieli (1998).

Language, like memory, is not unitary. It encompasses implicit linguistic competence and metalinguistic knowledge (Paradis, 1994, 1997, 1998a, 1998b, 2004). According to Paradis, metalinguistic knowledge is learned consciously and can be recalled into consciousness. It is applied in a controlled manner in language processing and relies on declarative memory, which has been reported by Cohen and Squire (1980) to depend on the integrity of the hippocampal system, and to be stored diffusely over large areas of tertiary cortex. Ullman (2001) refers to aspects of language to which these characteristics apply as the "memorized mental lexicon". The lexicon refers to the repertory of words or of idiomatic expressions (e.g., to kick the bucket), whereby a sound (or sounds) is paired with a referential meaning. It is equivalent to vocabulary. Paradis (2004) defines the lexicon as "the set of words represented in the brain, including their default meanings and their implicit phonological, morphological and syntactic properties" and he indicates that "implicit aspects of the lexicon are part of the grammar (implicit linguistic competence)" whereas "aspects that are consciously observable or teachable are refered to as vocabulary". In this manuscript, the lexicon refers to sound-meaning pairs and not to grammatical word features (e.g., the French words "chaise" being feminine).

By contrast, implicit linguistic competence is acquired in an incidental manner. According to Paradis (1994), it is stored in the form of procedural "know-how", without awareness of its contents. It is used automatically and relies on procedural memory, which, according to Cohen and Squire (1980) is mediated by subcortical structures, mainly the basal ganglia and cerebellum. Ullman (2001) refers to aspects of language to which these characteristics apply as the "computational mental grammar". In a native language (L1), conversation requires the concurrent activation of declarative memory, responsible for lexical processing, and of procedural memory, responsible for grammatical processing.

In a second language (L2), the extent to which grammar recruits procedural memory is thought to depend on at least three factors, according to Paradis (1997): The age and context of acquisition, the degree of mastery, and the degree of motivation in acquiring L2. According to Paradis (1997), a later age of acquisition, limited mastery, and restricted practice in a conversational setting, are associated with decreased implicit linguistic competence in L2 and with increased reliance on metalinguistic knowledge and pragmatics in the processing of an L2. Evidence that the lexicon, and L2 grammar when it is learned after puberty, are subserved by declarative memory, and that L1 grammar is dependent upon procedural memory, is reviewed extensively by Paradis (2004) and Ullman (2001). One way to examine this proposal is to study languages in bilingual patients with damage to parts of the declarative memory system and in bilingual patients with lesions in areas of the procedural memory system. Based on the fact that Alzheimer's disease (AD) affects mostly the neural substrate of declarative memory, and Parkinson's disease (PD) affects the neural substrate of procedural memory (see Gabrieli, 1998, for a review), the following predictions can be made for an L2 learned late: AD is expected to affect L2 grammar more than L1 grammar, since L2 grammar depends on declarative memory and L1 grammar on procedural memory, whereas PD is expected to affect mostly L1 grammar, since it depends on procedural memory. Only AD is expected to affect the lexicon, equally so in L1 and L2.

These predictions have not yet been tested using free speech samples from bilingual AD and PD patients. Many studies have examined picture description in AD (Bayles, Tomoeda, & Trosset, 1991; Croisile et al., 1996; Duong, Giroux, Tardif, & Ska, 2005; Giles, Patterson, & Hodges, 1996; Kave & Levy, 2003; Forbes, Venneri, & Shanks, 2002; Hier et al., 1985; Nicholas, Obler, Albert, & Helm-Estabrooks, 1985; Ripich, Fritsch, Ziol, & Durand, 2000; Smith, Chenery, & Murdoch, 1989; Tomoeda & Bayles, 1993; Tomoeda, Bayles, Trosset, Azuma, & McGeagh, 1996) and one in PD (Murray, 2000), but none have examined the L2 performance of AD or PD patients on this task. Below is a brief review of the literature on memory and language in AD and PD, preceded by a summary of the research findings on memory and language in healthy aging. This study examines not only the effects of AD and PD, but also the effects of aging, on speech in L1 and L2, to help delineate the contribution of aging and that of AD and PD. The literature review is then followed by an overview of the current study.

Memory and Language in Healthy Aging

Research on cognition in aging provides evidence of age-related changes in attention and memory, as described in Craik and Byrd (1982). Aging has been associated with a decrease in the episodic aspects of declarative memory, such as memory for temporally dated episodes (Flicker, Ferris, Crook, Bartus, & Reisberg, 1986). By contrast, the semantic aspects of declarative memory, such as memory for facts, concepts, and vocabulary, as well as procedural memory, have been shown to be relatively immune to the effects of healthy aging (Flicker et al., 1986; Smith & Fullerton, 1981). Semantic memory is more closely related to the lexicon than episodic memory is, as most people remember the meanings of words they have learned but not necessarily the where, when, or how, they learned the meanings of those same words.

Despite the fact that vocabulary size can increase throughout the middle adult years, word-finding difficulties have been well documented in older adults on naming tasks and on semantic and letter fluency tasks (Albert, Heller, & Milberg, 1988; Au, Joung, Nicholas, Obler, Kass, & Albert, 1995; Bowles, Obler, & Albert, 1987; Nicholas et al., 1985; Sliwinski & Buschke, 1999; Welch, Doineau, Johnson, & King, 1996). Older adults are more susceptible to the tip-of-the-tongue phenomenon (e.g., Heine, Ober, & Shenaut, 1999). Lexical processing has also been vastly investigated in priming paradigms, which contrast the time it takes to recognize a target (e.g., bread) when it follows a lexical associate (e.g., butter) versus when it follows an unrelated word (e.g., lamp). In a meta-analysis of priming effect in older adults, Laver & Burke (1993) show that semantic priming effects are smaller for younger than for older adults. Cameli and Phillips (1999) provide Event-Related Brain Potential (ERP) evidence of decreased semantic priming effects in older adults in the processing of single words.

Davidson, Zacks, & Ferreira (1996) found sentence production to be well preserved in older adults, in a stem completion task. By contrast, Kemper, Rash, Kynette, and Norman (1990) found evidence of an age-related simplification of grammar, a finding replicated by others (e.g., Cooper, 1990; Kemper, Herman, & Lian, 2003; Kemper, Kynette, Rash, Sprott, & O'Brien, 1989; Kemper, Marquis, & Thompson, 2001; Kemper & Rash, 1988; Kynette & Kemper, 1986; Lyons, Kemper, LaBarge, Ferraro, Balota, & Storandt, 1994). An example of grammatical simplification is that relative to younger adults, older adults avoid left-branching constructions (e.g., "The woman who runs a nursery school is awfully young"; versus right-branching: "The woman is young to be running a nursery school"; Kynette & Kemper, 1986). In autobiographical narratives, relative to a younger cohort, older adults have been shown to use more indefinite wording, to be more verbose, and to produce more off-topic speech (Cooper, 1990; James, Burke, Austin, & Hulme, 1998; Pushkar, Basevitz, Arbuckle, Nohara-Leclair, Lapidus, & Peled, 2000).

The nature of age-related changes in a second language remains unknown, with only two studies having examined linguistic abilities in older bilinguals. Juncos-Rabadan (1994) administered the Bilingual Aphasia Test (BAT) to sixty Galician-L1 and Spanish-L2 bilinguals, separated into three age groups: 30-40, 50-59, and 70-90 years-old. The age and context of acquisition of L2 was not specified. The hypothesis was that if age-related changes in language are due to decrements in attention or working memory, then the L1 and L2 performance of older adults should be similar. Each group performed better in L2 than in L1 on the tests, but the oldest group showed reduced performance relative to the youngest group in both L1 and L2, which they interpret as supporting the notion that a reduction in attention or memory is a source of age-related decrements in language. Juncos-Rabadan & Iglesias (1994) analyzed data from 840 participants on the BAT, in 14 languages. The participants were separated into three age groups: 50-59, 60-69, and 70-91 years-old. Juncos-Rabadan & Iglesias (1994) reported that aging was associated with linguistic deterioration at all levels, including phonology, morphology, syntax, the lexicon, and semantics, equally so in L1 and L2. The authors conclude, as did Juncos-Rabadan (1994), that age-related linguistic changes are due to attentional limitations or restrictions of working memory, although each study did not measure attention or memory.

Summary: In sum, the L1 literature suggests that aging affects subtle grammatical processing in discourse production, with older adults favoring simpler grammatical structures, as well as lexical processing, with older individuals producing more indefinite words and displaying word-finding difficulty. Processing limitations, from reduced working memory, inhibitory deficits, or slower processing speed, all associated with healthy aging, have been shown to be implicated in age-related linguistic differences (e.g., Kemper, Herman, & Liu, 2004). Findings in the bilingual literature would suggest that aging may have a comparable effect on L1 and L2, assuming similar proficiency.

Memory and Language in AD

A hallmark of AD is declarative memory deficits, which occur in the context of relative sparing of procedural memory, based on evidence reviewed in Gabrieli (1998).

At the word level, AD patients exhibit naming deficits (Appell, Kertesz, & Fishman, 1982; Huff, Corkin, & Growdon, 1986; Nicholas et al., 1996) and decreased word fluency (Martin & Fedio, 1983). They are less accurate than older controls at matching words to pictures (Hodges, Salmon, & Butters, 1992) and at making semantic relatedness judgments (Silveri, Monteleone, Burami, & Tabossi, 1996).

While there is consensus that the lexicon is affected by AD (Appell, Kertesz, & Fishman, 1982; Huff, Corkin, & Growdon, 1986; Martin & Fedio, 1983; Nicholas et al., 1996), there is less agreement regarding the status of grammar in AD. Some researchers (e.g., Kempler, Curtiss, & Jackson, 1987) have found syntactic processing to be relatively well preserved in AD, but others have found syntactic processing to be impaired in AD (see Emery, 1996). It has been proposed that the syntactic difficulties in AD may be due to limited processing capacity, consequent to a working memory deficit, rather than to an impairment of syntactic functions per se, because the performance of AD patients on tests of syntactic comprehension has been shown to be sensitive to the number of propositions but not to the syntactic complexity of the sentences (Grossman & White-Devine, 1998; Small, Kemper, & Lyons, 2000; Waters, Caplan, & Rochon, 1995; Waters, Rochon, & Caplan, 1998).

Matthews et al. (1994) compared the free speech of AD patients to that of Wernicke aphasics, as it typically contains a high proportion of words and utterances that convey little or no information, many closed-class phrases and ill-defined pronouns, as well as frequent interruptions (Almor, Kempler, MacDonald, Andersen, & Tyler, 1999; Cummings, Darkins, Mendez, Hill, & Benson, 1988; Hier, Hagenlocker, & Shindler, 1985; Illes, 1989; Nicholas et al., 1985). Bucks et al. (2000) conducted a Principal

Components Analysis on data from the spontaneous speech of AD patients. The authors identified two principal components: Word finding difficulty and poverty of word content. However, the AD patients in their study displayed an adequate generation of adjectives, pronouns and verbs, and a good ability to construct sentences.

Many studies have elected to use picture description to investigate the speech of AD patients (Bayles et al., 1991; Croisile et al., 1996; Duong et al. 2005; Giles et al., 1996; Kave & Levy, 2003; Forbes et al., 2002; Hier et al., 1985; Nicholas et al., 1985; Ripich et al., 2000; Smith et al., 1989; Tomoeda & Bayles, 1993; Tomoeda et al., 1996). As Forbes et al. (2002) point out the method reduces the interference from memory impairments since the stimulus is available to the patient, and allows the examiner to readily identify speech errors, such as naming mistakes and irrelevant themes. Several of the studies have used the Cookie Theft Picture (Croisile et al., 1996; Giles, Patterson, & Hodges, 1996; Hier et al., 1985; Kave & Levy, 2003; Nicholas et al., 1985; Ripich et al., 2000) from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). The findings from these studies converge to demonstrate a decrease in information units or other measures of meaning, and fewer specific words used (Bschor, Kuhl, & Reischie, 2001; Croisile et al., 1996; Ehrlich, Obler, & Clark, 1997). In addition, some have shown a reduction in the number of words used and the number of unique words (e.g., Hier et al., 1985), shorter utterances (e.g., Ripich et al., 2000), as well as a reduction in the number of subordinate clauses (Croisile et al., 1996).

Despite the fact that half of the world population is bilingual or multilingual according to Fabbro (1999), only eight studies have examined how AD affects a native versus a second language (De Vreese et al., 1988; Dronkers et al., 1986, cited in

Hyltenstam & Stroud, 1993; Friedland & Miller, 1999; Hyltenstam & Stroud, 1989, 1993; De Picciotto & Friedland, 2001; De Santi et al., 1989; Meguro et al., 2003). De Piciotto and Friedland (2001) compared the performance of six Afrikaans-English bilingual AD patients to that of thirty healthy older bilinguals on a semantic fluency task. The participants generated as many animal names as possible within one minute, in L1 and in L2, as well as in bilingual mode. AD patients appeared to have generated fewer items within L2 than within L1, but this was not supported statistically. The authors indicate that L1 was the language most used by the participants at the time of the study, which may explain their greater fluency in L1. Meguro et al. (2003) examined various linguistic functions in a sample of four Japanese-Portuguese bilinguals, and report that they were more impaired for words with an irregular spelling than for words with a regular spelling, in both Japanese and Portuguese. These two studies do not provide strong evidence for selective or non-selective L1 or L2 degradation of lexical processing.

Six of the eight studies have examined discourse in bilingual AD. Hyltenstam & Stroud (1989) examined qualitative differences in topic treatment, lexical availability, automatic speech, and communicative strategy, in a German-Swedish bilingual AD patient who had acquired L2 at middle age, and a Swedish-Finnish bilingual AD patient who had acquired L2 at a pre-school age. They report that the patient who had learned L2 at middle age conversed better in L1, whereas the one who had learned L2 at a pre-school age performed similarly across the two languages. Dronkers et al. (1986; conference proceeding cited in Hyltemstam & Stroud, 1993) report on a Dutch-English bilingual AD patient whose language abilities were affected equally in L1 and L2. This result diverges from De Santi et al. (1989) who report on four English-Yiddish bilingual

AD patients, tested on speech, repetition, reading, and writing, who exhibited different linguistic difficulties in L1 and L2. De Vreese et al. (1988) report on an Italian-French bilingual AD patient who tended to translate spontaneously into L2, which the authors suggest may have indicated unintentional access to L2. The remaining two studies have been concerned with code-switching behavior, which refers to using words from another language in the course of conversation in a given language (i.e., switching to the other language). Friedland and Miller (1999) tested four English-Afrikaans bilingual AD patients ranging from mildly to moderately demented. They measured code-switches in 10-minute conversations, held once in Afrikaans (L1) and once in English (L2). The authors report that code-switching did not correlate with stage of dementia. Hyltenstam & Stroud (1993) examined code-switching during conversation in six Finnish-Swedish bilingual AD patients, and found L1 and L2 to be comparably affected overall. In his review of the code-switching literature, Hyltenstam (1995) concludes that code-switching is not a necessary consequence of dementia, and that in some cases patients may be more likely to revert to L1 because an L2 learned in adulthood may be more affected by the limited processing capacity associated with dementia. As can be seen from the bilingual dementia literature, the findings are disparate. Sample sizes vary from one to six for bilingual AD, and language characteristics such as L2 age of acquisition, proficiency and use, are not always well specified. In sum, we do not at the moment, have a clear picture of how AD affects the lexicon and grammar in L1 and L2.

Summary: In L1, there is considerable evidence that AD affects lexical processing, but whether or to what extent the disease affects grammar remains debatable. How AD affects an L2 is only beginning to be examined. Much of the research involves case studies and has focused on code-switching. It is not clear from the bilingual literature whether AD affects L1 and L2 equally, when L2 is learned late, or whether it predictively selectively affects L1 or L2 to a greater extent.

Memory and Language in PD

Non-demented PD patients have been shown to have impaired procedural memory (e.g., Westwater, McDowall, Siegert, Mossman, & Abernethy, 1998), in the context of relatively spared declarative memory (Gabrieli, 1998). The effect of PD on language has been less extensively researched than that of AD, and initially, it was thought that PD was not associated with language impairment (e.g., Webster Ross, Cummings, & Benson, 1990). Since then, impairments in syntactic comprehension have been well documented in PD (Grossman, 1999; Hanes, Andrewes, & Pantelis, 1995; Lewis et al., 1998; McNamara, Krueger, O'Quin, Clark, & Durson, 1996; Murray & Stout, 1999). It is not clear whether PD affects the lexicon. PD patients have been shown to be impaired in confrontation naming and fluency tasks (Bamford et al., 1995; Starkstein et al., 1996; Stern et al., 1998), but these tasks usually involve a speed component and PD patients display reduced processing speed relative to healthy older adults (Grossman et al., 2002). The cognitive status of patients may affect how language deficits manifest. Lewis et al. (1998) found that PD patients with below normal cognitive status, based on the Mattis Dementia Rating Scale, displayed deficits in naming and in fluency, but PD patients with normal cognitive status did not.

The discourse of PD patients is marked by grammatical simplification. Phrase length tends to be reduced, and fewer dependent clauses and open-class phrases are produced (Cummings et al., 1988; Illes, 1989; Illes, Metter, Hanson, & Iritani, 1988).

The free speech description of a complex picture has also been examined in PD. Murray (2000) administered the Cookie Theft picture to a group of 10 PD patients. Grammatical impairments were limited to a smaller proportion of grammatically correct sentences. PD patients also produced fewer information units. To our knowledge, only one study has examined language function in bilingual PD patients. Zanini et al. (2004) demonstrated greater syntactic impairments in L1 relative to L2 in twelve Friulian-Italian bilingual PD patients using tests of sentence comprehension and syntactic judgment. In short, PD, which leads to procedural memory deficits, seems to clearly impact grammar, perhaps more so in L1 than in L2, and to spare the lexicon. However, previous studies have not measured declarative and procedural memory, and administered language tests in L1 and L2, concomitantly, in bilingual AD and PD patients.

This Study

The evidence reviewed from studies on language in AD and PD is consistent overall with the proposal that in a native language, the lexicon is subserved by declarative memory and grammar by procedural memory. AD patients, who are believed to sustain declarative memory deficits, seem to be most impaired on lexical measures, although some grammatical impairments have also been documented. By contrast, PD patients, who are thought to display procedural memory deficits, seem most impaired on grammatical measures and not on lexical ones. The impact of PD on L2 production has not been examined yet, and it is not clear whether AD has a greater effect on L1 or L2.

In this study, we contrasted the Cookie Theft picture description performance of balanced bilingual AD and PD patients to that of healthy controls in an L1 and an L2. Tests of declarative and procedural memory were administered to document selective declarative memory deficits in the AD group and selective procedural memory deficits in the PD group. Based on recent neurolinguistic models of the lexicon and grammar in bilinguals (Paradis, 1994, 2004; Ullman, 2001), AD patients were expected to be impaired on lexical measures, equally so in L1 and L2, and on grammatical measures mostly in L2. PD patients were expected to be selectively impaired in L1 grammar. The contribution of aging was inferred from the L1 and L2 performance of the healthy older controls relative to that of a group of healthy young bilinguals. Lexical measures are used to refer to word level measures, and include the percentage of unique words and unique nouns, the percentage of pronouns relative to nouns, lexical errors, and percentage of open-class words. Grammatical measures refer to sentence level measures, and include the number of words per utterance, the percent of utterances that are subordinates, the percent of correct utterances and grammatical errors. Discourse level measures were examined, which include measures of information and verbosity, which were expected to be mostly affected by AD, irrespective of language.

Method

Participants

Sixteen healthy young controls (YC) and 16 healthy older controls (normal controls: NC), 8 AD patients, and 8 PD patients, were tested. AD patients were referred from a Memory Clinic, after having been thoroughly assessed by a neurologist who specializes in the diagnosis and treatment of dementia. Many of the AD patients were taking Aricept, and some were also taking Asaphen. AD patients had MMSE scores ranging from 16 to 27, with an average of 23. At least four were within the minimal range of impairment (24-29), two within the mild range (17-23), and one within the moderate range (3-16). The MMSE was not available for AD 3, but the patient underwent a full neuropsychological evaluation at the Montreal Neurological Institute, which confirmed a diagnosis of probable AD. Information on health and language volunteered by the AD patients was verified with their spouses, when possible. Seven of the eight AD patients were right-handed and one was ambidextrous, and six were men. Age, education and linguistic characteristics are reported in Table 1. Please consult Appendix C for more information on individual patients.

PD patients were referred from a Movement Disorder Clinic, again, after having been carefully diagnosed by the referring neurologist who specializes in the assessment and treatment of movement disorders and has years of experience in research on PD. The medication taken by the PD patients included Sinemet, Amantadine, Permax, and Levadopa. All PD patients were medicated and each was tested at a time of day when he/she reported the symptoms were least. On the Hoehn and Yahr scale (Hoehn & Yahr, 1967), five, and likely six, PD patients were in Stages 1 and 2, whereas two were in

Table 1. *Characteristics of the participant groups.*

	YC	NC	NCAD	AD	NCPD	PD
Sample size	16	16	8	8	8	8
Age range	19-32	52-74	65-74	58-83	52-74	55-79
Mean age	25	65	70	76	66	65
	(3.52)	(5.86)	(3.11)	(9.01)	(7.75)	(9.36)
Education (in years)	16 (2.39)	16 (2.64)	16 (2.03)	12 (2.55)	16 (2.73)	15 (4.37)
Having French as L1	13	13	7	7	8	6
Mean age felt fluent in L2	13 (4.51)	20 (4.19)	16 (3.76)	13 (4.81)	20 (4.58)	20 (4.98)
Range age felt fluent in L2	6-19	8-45	8-20	6-18	14-20	15-30
Mean percent of the time spent in L2 currently	55	47	50	50	48	39
	(21.39)	(16.07)	(18.32)	(18.08)	(11.97)	(9.58)

Note: SDs are presented in parentheses.

YC = Young controls. NC = Older normal controls.

NCAD = Normal controls for the AD group.

NCPD = Normal controls for the PD group.

Stages 3. None of the patients were in Stages 4 or 5. The PD patients in this study tended to be in the earlier stages of impairment than those in some studies (e.g., Murray, 2000), but comparably impaired to those in other studies (e.g., Arnott et al., 2005). The Hoehn and Yahr rating was not available for PD 4, because the patient had not been treated at the referring clinic for some time, but a diagnosis of PD had been established by the referring neurologist. PD patients were selected who were not demented because dementia in PD could indicate concomitant AD, or another disorder altogether. Seven of the eight PD patients were right-handed and one was ambidextrous. Four PD patients were men. Age, education and linguistic characteristics are reported in Table 1. Please consult Appendix C for more information on individual patients.

Healthy participants were recruited through advertisements. Participants were screened for major past or current health or mental problems (see the Health Questionnaire in Appendix A). Those with conditions known to affect cognition (other than AD and PD) were excluded. Ethical approval was obtained and all participants, and caregivers in the case of AD patients, gave informed consent. All participants were French-English or English-French bilinguals. Bilingualism was assessed with the History of Bilingualism questionnaire (see Appendix A), and the English Background and French Background questionnaires from the Bilingual Aphasia Test (Paradis, 1987). Generally, to be included in the study, participants had to report: 1) feeling equally or almost equally comfortable in English and French, 2) using L2 at least 30% of the time on a daily or weekly basis, and 3) having learned L2 enough to speak it fluently after puberty. All participants learned their L2 academically, with the exception of one young control, two healthy older controls, three PD patients and two AD patients who learned their L2 mostly through conversation. All participants learned their L2 after age 12, except for three YC and one NC participants, and three AD participants who learned their L2 at about 8 years of age. Since the AD group was older than the PD group, each group was appointed its own control group (NCAD and NCPD, respectively). For each patient, a participant from the NC group was selected to match best that patient's demographic characteristics. Four of the participants from the NC group each served a healthy control for both an AD and a PD patient. This procedure can lead to a small increase in Type I error, but was necessary to ensure that each patient had a matched control participant which resembled him/her most on demographic and linguistic characteristics. Characteristics for each patient group and its control group are reported in Table 1, and for each pair of patient and his/her matched control, in Appendix C. The PD group did not differ statistically from its control group on any of the variables presented in Table 1, i.e., mean age, years of education, age when became fluent in L2, and percent of current L2 use in daily life (t_s [14] = -.06, -1.03, .16, -1.61, respectively, $p_s > .05$). The AD group had significantly fewer years of education than its control group (t [14] = -3.36, $p < .05$), and became fluent in L2 at a slightly younger age than its control group did (t [14] = -2.43, $p < .05$), but both groups were of a comparable age (t [14] = 1.89, $p > .05$) and used L2 as frequently (t [14] = .04, $p > .05$). The younger and older groups did not significantly differ on years of education (t [30] = .49, $p_s > .05$) or current L2 use in daily life (t_s [30] = 1.35, $p_s > .05$), but differed on the age at which they became fluent in L2 (t_s [30] = , $p < .05$) and age (t_s [30] = -23.69, $p_s < .05$).

Declarative and Procedural Memory Tests

Memory was assessed in each participant's L1 in the non-verbal and verbal domains. Only tests that do not require a manual response were selected. Declarative memory was assessed in the non-verbal modality with the Batterie d'Efficience Mnésique (BEM-144; Signoret, 1991) and in the verbal modality with the Rey Auditory Verbal Learning Test (RAVLT; Lezak, 1983). The BEM required subjects to recognize simple designs, whereas the RAVLT required them to learn and remember a list of simple nouns. The RAVLT has been shown to be sensitive to AD (see Spreen & Strauss, 1991). The BEM has not been used in research on AD to our knowledge, but it was chosen because it does not require subjects to draw, as opposed to more commonly used tasks that require copying a figure and/or drawing it from memory after a delay.

Procedural memory was evaluated in the non-verbal modality with the Serial Reaction Time task (SRT; Westwater et al., 1998) and in the verbal domain with the Mirror-Reading task (Deweer, Ergis, Fossati, Pillon, Boller, Agid, & Dubois, 1994). The SRT is a measure of sequence learning. The participant tracked a star that appears on a computer monitor following a spatial sequence. Participants are usually unaware of the sequence yet their tracking speed increases with increasing exposure to the sequence. The mirror-reading task measures the acquisition of the ability to read words printed backwards. These tasks were chosen because they have been shown to be sensitive to PD (Westwater et al., 1998 for the SRT; Koenig, Thomas-Anterion, & Laurent, 1999 for the mirror-reading task) but not to AD (Knopman & Nissen, 1987 for the SRT; Deweer, Pillon, Michon, & Dubois, 1993 for the mirror-reading task).

BEM: This test required subjects to recognize 24 simple and abstract designs. Each black and white design measured 6 cm^2 and was printed on a separate 8.27 X 11.69 in. page. Each design was presented for 5 s and the participant was asked to observe it carefully because it would have to be recognized among 3 foils later. After a 30-minute delay, each of the 24 designs was presented among 3 foils. Each black and white design measured 6 cm^2 and each foil appeared only once. The participant was told that he/she had seen one of the four designs, presented in one column on the page, and asked to point to the one he/she recognized. The number of designs correctly recognized was measured.

RAVLT: This test required subjects to learn and remember a list of words. The participant heard a list of 15 familiar nouns (List A), read at a rate of one word per second, and was asked to recall as many as possible in any order. This procedure was repeated five times. For each recall, the minimum time allowed was 45 s and the maximum was 2 min. After the five trials, the participant heard another list of 15 words (List B) and was asked to recall as many words as possible from this list only. Following this interference trial (i.e., List B), the participant was asked to recall the words from List A. Following a 30-minute delay, recall was tested unexpectedly for List A and recognition evaluated for Lists A and B. For the recognition test, List A and B words were presented among 20 foils. Some of the foils were semantic associates of the target words whereas others were phonetic associates. The French version of the RAVLT was obtained from M. Jonesgotman. There were six measures of interest: 1) The number of words recalled on the first learning trial, 2) The number of words recalled on the final learning trial, 3) The total number of words recalled across the five learning trials, 4) The number of words recalled after interference, 5) The number of words recalled from List A after the delay, and 6) The number of words from Lists A and B correctly recognized.

SRT: This test of sequence learning was implemented as described in Westwater et al. (1998). On each trial, an asterisk appeared at one of four locations at the bottom of the computer monitor. The four locations (1, 2, 3, 4) were equidistant along the horizontal axis. The asterisk appeared on the monitor in the following 10-trial sequence: 4231324321. Upon a response, the asterisk disappeared and 400 ms later it reappeared at a different location for the next trial. There were five blocks of trials. The first four blocks comprised 10 repetitions of the 10-trial sequence. The fifth block consisted of 100 trials presented in random order with the constraint that the asterisk did not appear at the same location consecutively. The blocks were separated by a 1-min pause. Before initiating the task, the participant was shown the four locations and was then instructed to name the location out loud as soon as the asterisk appeared on the monitor. Naming latency was recorded through Inquisit (Millisecond Software). Upon completion of the task, the participant was asked whether he/she noticed anything and if he/she believed his/her naming latency decreased with practice. If the participant referred to a sequence, he/she was asked to tell the order.

Mirror-reading: This test of skill acquisition and repetition priming was implemented to resemble that described in Deweer et al. (1994). All words were six to seven letters long. Word frequency varied between 1 to 22 occurrences per million words in written language. Word frequency norms for the English version were taken from Francis and Kucera (1982), whereas those for the French version were collected from Beaudot (1992). There were three sets of stimuli, one for each learning session.

Each set consisted of 5 blocks of 10 word triads. Five word triads were unique to each block and five of the word triads were common to all blocks. The unique word triads were used to test skill acquisition, whereas the repeating triads were employed to assess repetition priming. In each block, the mean word frequency for the unique and for the repeat triads was of 8.6. The mean frequency for the first, second, and third words of triads was matched in each block and across blocks, and varied between 8.5 and 8.6. The mean frequency for each set of five unique triads in each block varied between 7.1 and 10.2. The frequency of each of the five repeat word triads varied between 5.3 and 13.7, for an average repeat triad frequency of 8.6. The order of the words in the repeat triads varied across the five sets in a block, such that it was never the same. This description of the stimuli applies to both the English and the French version. The triads were printed in black ink upper case in a 53-point size Arial font using Microsoft Word 2000. Accents were included for the French version. The words in each triad were separated by a hyphen (e.g., SLEEVE-KENNEL-TWISTER). Using Adobe Photoshop 5.5, each triad was flipped over a vertical axis, and printed on a transparency for presentation to the participants. Each 8 ½ X 11 inch transparency was placed on top of an 8½ X 11 off-white sheet of paper. Participants were told that the words had been flipped on a vertical axis and that therefore words had to be read from right to left. If the participant did not understand, the transparency was flipped to show a practice item in normal orientation. Two single-word practice trials were given, as well as one practice trial with a word triad. Participants were encouraged to read each triad as fast as possible. If a participant made an error, he/she was asked to correct the error. The time it took each subject to read each triad was measured with a stopwatch. A maximum of 2 min was allowed to read a triad.

Each block of 50 triads was interspersed with other tasks. After completing the three blocks of 50 triads, recognition was tested for the triads that were common to all blocks. There were five triads that were present for each set of 10 triads, in each block. This means that 15 words were repeated throughout the task. For the recognition test, these 15 words were embedded in 30 foils neither semantically nor phonetically related to the repeat words. The average frequency of the foils was of 8.6, the same as that of the repeat words. After the mirror-reading task, each of the 45 words was printed forward (i.e., not flipped) on an 8 ½ X 11 white sheet of paper in the same font as the other stimuli. The participant was shown each word and asked if he/she had read the word backward earlier in the test.

Apparatus and Software for the SRT

For the SRT, participants were tested either on a Pentium 1 IBM Thinkpad model 385XD, at study onset, or on a Dell Inspiron 5100, in the final years of the study, with each participant being tested always with the same computer. The monitor of the IBM Thinkpad measured 12 in and that of the Inspiron measured 15 in. Inquisit version 1.32 was used to run the SRT (Millisecond software). A close-talk microphone headset (model Andrea NC-8) recorded the participant's responses.

Testing Procedure

Participants were offered to perform the tests in the laboratory or in their home. Two healthy older adults, five PD patients, and all AD patients elected to be tested at home. Each participant was tested over three separate days in sessions that lasted approximately 2 ½ hours each. Participants were given breaks as needed and given $45 for their participation. For each session, a native speaker administered the tests, with the exception of four young controls who were tested by a highly proficient French-English bilingual. Memory was evaluated in each participant's L1, generally on the first day. For the memory session, the participant completed Session 1 of the mirror-reading task, followed by the learning phase of the RAVLT and BEM. Session 2 of the mirror-reading task was then carried-out, followed by the memory phase of the RAVLT and BEM. Session 3 of the mirror-reading task was then administered and the participant completed the SRT. The order of administration of the RAVLT and BEM was counterbalanced such that approximately half of the participants in each group began with the RAVLT and half with the BEM. The French and English versions of the Picture Description task were administered on separate days, following completion of the Past Tense Generation task (see Cameli, Phillips, Kousaie, Panisset, & Nasreddine, in preparation, for the past tense generation results). For the Picture Description task, each participant was asked to orally describe the Cookie Theft picture from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). For the French test, the word "biscuits" replaced the words "cookie jar", on the picture. The instructions were "I would like you to tell me what is going on in this picture". Instructions were given in French for the French testing session and in English for the English one. Participants were told that their speech would be recorded on audiotape, and this was done using a General Electric tape recorder model No. 3-5383A. The examiner nodded and smiled appropriately, but did not say any word during the speech production. If participants asked if they had spoken enough, the examiner indicated that this was for the participant to decide. Speech was transcribed from the audiotape by a native speaker for each language. Five YC and six NC participants were tested in L2 first. Three AD patients and five PD patients were tested in L2 first, as were three NCAD and three NCPD participants. On average, the two language sessions were separated by 9 days for the YC and 9 days for the NC groups (with the exception of 154 days for one YC participant), and by 8 days for the PD group and by 10 days for the AD patients.

Language Coding Procedure

The scripts were coded by a team of psychology undergraduate students and the coding reviewed by the authors. For each participant, the English and French scripts were coded by a native speaker of the language, and the measures calculated separately for each language. Each measure is summarized in Table 3. At the word level, the following measures were examined: The percent of unique nouns and unique words, and the percent of pronouns relative to nouns. Naming errors were measured, as was the percent of open-class words. At the sentence level, grammatical complexity was inferred from the number of words per utterance and the proportion of subordinate clauses. The percent of correct utterances was measured, and grammatical errors were examined. At the discourse level, the amount of information provided by the participants was assessed, and verbosity was inferred from the total number of utterances and words. Stereotypical utterances like "I don't know" and "what else?" were excluded from the coding, and each word was coded under one of these categories only: noun, verb, open-class adjective, open-class adverb, pronoun, auxiliary, or closed-class word.

Word Level Measures

Percentage of Unique Nouns: A noun was defined as a word that names a person, place, idea or thing, and/or, while not a pronoun, occurred in a subject or object position. For example, in "Outside seems to be", "outside" was considered to be a noun. A compound noun, defined as two nouns that named a single person, place, idea or thing, counted as one entry. Examples include "cookie jar", "counter top", "tea cups". A measure of type and of token was obtained, such that if the noun "cookie" was spoken five times, for instance, it yielded one noun type and five noun tokens. The percent of Unique Nouns was calculated by dividing the number of noun types by the number of noun tokens, multiplied by 100. A participant with a richer vocabulary is expected to produce many unique nouns, relative to all the nouns generated.

Percentage of Unique Words: The percent of unique words equals the number of unique types of *nouns*, *verbs*, *open-class adjectives*, and *open-class adverbs*, divided by the total number of tokens of nouns, adverbs, open-class adjectives and open-class adverbs, multiplied by 100. The percent of unique words was used as a second measure of richness of vocabulary. A participant with a richer vocabulary is expected to produce many unique words, relative to all words used.

A verb was defined as a word that expresses action, condition, or state. Elements of verbal expressions commonly used counted as one verb. In other words, the noun element of the verbal expression did not count as a noun. Most instances occurred in French. Examples include the French verbal expressions "*avoir l'air*" (to seem), "*faire signe*" (to signal), and "*rendre compte*" (to notice). The verb count yielded a type and a token measure. If for instance, the verb "wash" was spoken five times, it yielded one verb type and five verb tokens. Different inflectional markings of a verb (e.g., talk, talks, talked, talking) were counted as the same type. Auxiliaries were coded separately as closed-class measures. An auxiliary was defined as a verb that indicates tense or mood and precedes a verb. Auxiliaries included "should, must, can, might, may, seem, could,

Table 2. *Summary of the speech measures*

<u>Word level Measures</u>

- Words: Percentage of Unique Nouns
- Nouns: Percentage of Unique Words
- Pronouns: Ratio of Pronouns to Nouns
- Lexical Errors:
  - As a Percent of Total Errors
  - Relative to the Number of Utterances
- Percent Open-Class Words

<u>Sentence level Measures</u>

- Words per Utterance
- Proportion of Subordinate Clauses
- Percent of Correct Utterances
- Grammatical Errors:
  - As a Percent of Total Errors
  - Relative to the Number of Utterances

<u>Discourse level Measures</u>

- Information units
- Number of Utterances
- Number of Words

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would, will" in English and "est, a, doit, peut, va, veut, fait, semble" in French, and any inflectionally marked form of these. For instance, in "The mother does not seem to realize...", "realize" was coded as the verb whereas "does" and "seem" were coded as auxiliaries.

An *adjective* was defined as a word that modifies a noun. A few compound adjectives were identified, such as "fair haired". Exceptionally, a noun or compound noun was coded as an adjective when it clearly modified a noun, as in "*shoulder length* hair". The percent of open-class adjectives yielded two measures: type and token. If for instance, the adjective "tall" was said twice, it yielded one adjective type and two adjective tokens. Different inflectional markings of an adjective (e.g., small, smaller, smallest) were counted as the same type. Past participles counted as adjectives (e.g., she is "distracted"). Closed-class adjectives were counted under the closed-class words category, such as quantifiers (e.g., all, some, three, very, etc.). Finally, an *adverb* was defined as a word that modifies a verb. Open-class adverbs were defined as those ending with "ly" in English and "ment" in French. Examples include "probably", "leisurely", and "actually". Given that these were relatively few, only token was measured, and type was assumed to be equal to token.

<u>Percentage of Pronouns Relative to Nouns</u>: A pronoun was defined as a word that stands for, or replaces, a noun. Examples are "she" and "his". "Which" and "who" were scored as pronouns. "That" was scored as a pronoun whenever it could be replaced by "which" or "that which". The percentage of pronouns relative to nouns was calculated by dividing the total number of pronouns by the total number of nouns, multiplied by 100. This measure indicates how many pronouns a participant used in his/her description of

the Cookie Theft picture relative to the number of nouns used. The smaller the percentage of pronouns relative to nouns, the more the participant favored a noun over a pronoun to refer to the persons, objects, or places, in the picture. An individual experiencing lexical difficulty would be expected to use more pronouns and fewer nouns, resulting in a larger percentage of pronouns relative to nouns.

Lexical Errors: These refer to naming errors, i.e., using the wrong word label for an item (e.g., calling the "stool" a "bench"). These were examined relative to the total number of errors, and relative to the total number of utterances. The number of lexical errors relative to the total number of errors, multiplied by 100, indexes what percentage of the errors made by a participant were of a lexical nature, versus those of a grammatical or unknown nature (defined under the "grammatical errors" on page 33). The number of lexical errors relative to the total number of utterances, multiplied by 100, indexes what percentage of the utterances contained a lexical error, on average.

Percent of Open-Class Words and Percent of Closed-Class Words: Open-class words were defined as those belonging to a category of words that can be expanded in time, whereas closed-class words were defined as those belonging to a category of words that cannot be expanded over time. For instance, the adjective "fabulous" is open-class, whereas the adjective "two" is closed-class. The percent of open-class words equals the number of nouns, verbs, open-class adjectives and open-class adverbs, divided by the total number of words, multiplied by 100. The percent of closed-class words equals the number of closed-class adjectives, closed-class adverbs, auxiliaries, determiners, complementizers, and other functors, divided by the total number of words, multiplied by

100. Open-class words are associated with lexical processing, whereas closed-class words are associated with grammatical processing.

Sentence Level Measures

Words per Utterance: An utterance was defined as a series of words that contains a verb, could stand on its own, and has meaning. The number of words per utterance equaled the number of words in the speech sample divided by the number of utterances. The number of words per utterance provides an index of grammatical complexity, with more complex sentences resulting in a greater number of words per utterance and simpler sentences entailing fewer words per utterance.

Proportion of Subordinate Clauses: Subordinate clauses were defined as utterances that begin with a subordinating conjunction. Subordinating conjunctions included "although, because, if, since, while, whereas, when, which, through, and before". The proportion of subordinate clauses was obtained by dividing the number of subordinate clauses by the total number of utterances, multiplied by 100. This measure provides a second index of grammatical complexity, with increased complexity being associated with a higher proportion of subordinate clauses.

Grammatical Errors: This category included sentence level errors, such as incomplete sentences, errors in agreement between two words (e.g., "The little girl seem to be..."), omission of a necessary preposition, or using an incorrect determiner. Grammatical errors were examined relative to the total number of errors, and relative to the total number of utterances. The number of grammatical errors relative to the total number of errors, multiplied by 100, indexes what percentage of the errors made by a participant were of a grammatical nature, versus those of a lexical or unknown nature.

Errors of an unknown nature were those that could be either grammatical or lexical. An example is a sentence that were aborted before completion. It cannot be known whether the participant could not retrieve the word to come next in the sequence from his/her lexicon or whether he/she was unaware that the sentence as spoken was ungrammatical because it lacked a complement. The number of grammatical errors relative to the total number of utterances, multiplied by 100, indexes what percentage of the utterances contained a grammatical error.

Discourse Level Measures

Information Units: The 25 information units listed in Croisile et al. (1996), and Kave and Gitit (2003), were used. Three information units refer to the actors (mother, boy, girl); two refer to places (kitchen, exterior); thirteen refer to objects (faucet, water, sink, floor, plate, dishes on the counter, counter, cookies, jar, cabinet, stool, window, curtain); and seven refer to actions (boy taking the cookie, boy/stool falling, mother drying or washing the dishes, water overflowing, girl asking for a cookie, mother unconcerned by the overflowing, mother not noticing the children). For each speech sample, the total number of information units reported was added. The correct or exact word(s) was not required for an information unit to be counted. For instance, one point was alotted for "stool" even if the word "ladder" was used to refer to it. Rarely, an ambiguous response received half a point (e.g., "the boy is taking something" was given half a point for the information unit "boy taking the cookie"). Each participant received a score out of a total of 25, for each information unit mentioned, for each language. The score reflects how informative the speech sample was.

Total Number of Utterances and Words: Utterances have been defined previously. The total number of utterances and words in each speech sample was used as gross measures of talkativeness or verbosity. It additionally provides a measure of the size of the speech sample for each participant in each language.

Memory Results

For group comparisons, results from the NC group were compared to those from the YC group, results from the AD group to those from the NCAD group, and those from the PD group to results from the NCPD group. The memory results have been reported in Cameli et al. (in preparation) and include data from one additional PD patient who completed the memory tests but not the picture description task. One-tailed t-tests and ANOVAs were conducted at the .05 level of significance.

Batterie d'Efficience Mnésique (BEM): Scores in Table 2 represent the number of designs correctly recognized out of 24, divided by 2. Young adults recognized significantly more designs than did older adults ($t[30] = 2.01$, $p = .023$). The AD group recognized significantly fewer designs than did the NCAD group ($t[14] = 3.23$, $p = .000$), whereas the NCPD and PD group recognized a comparable number of designs ($t[16] = -0.90$, $p = .190$).

Rey Auditory Verbal Learning Test (RAVLT): Scores are reported in Table 2. T1 and T5 refer to the initial and final learning trials, respectively. Total refers to the average number of words recalled across all five learning trials. Relative to the NC group, the YC group tended to recall more words on the first learning trial, T1, ($t[30] = 1.62$, $p = .057$), and recalled significantly more words on the final learning trial, T5, ($t[30] = 2.89$, $p = .000$). The average number of words recalled across all learning trials, Total, was significantly higher for the YC group than for the NC group ($t[30] = 2.67$, $p = .006$). The NCAD group recalled significantly more words than the AD group on the T1 ($t[14] = 7.00$, $p = .000$), T5 ($t[14] = 5.76$, $p = .000$), and Total ($t[14] = 6.80$, $p = .000$), trials. In contrast, the NCPD and PD groups recalled a comparable number of words on

Table 2. *Mean scores and SEs on the BEM and RAVLT for each group*

	YC	NC	NCAD	AD	NCPD	PD
BEM (max=12)	10.75	9.56	9.88	6.38	9.56	10.22
	(.42)	(.39)	(.67)	(.85)	(.53)	(.51)
RAVLT						
T1	9.06	8.00	8.13	2.00	8.00	7.11
	(.55)	(.35)	(.61)	(.63)	(.53)	(.72)
T5	14.63	13.00	14.00	6.00	13.22	13.78
	(.20)	(.52)	(.53)	(1.28)	(.64)	(.60)
Total	64.06	57.81	59.75	21.38	58.44	53.33
	(1.47)	(1.82)	(2.76)	(4.93)	(2.57)	(2.50)
AI	14.00	11.56	12.75	3.12	11.89	10.44
	(.30)	(.66)	(.70)	(1.09)	(.90)	(1.06)
DR	14.13	11.63	12.88	3.63	11.67	11.22
	(.33)	(.55)	(.64)	(1.41)	(.71)	(.94)
DRe	14.94	14.50	14.88	8.25	14.67	14.67
	(.06)	(.20)	(.13)	(2.26)	(.17)	(.24)
FP	2.38	4.13	4.13	4.50	4.33	3.44
	(.65)	(.50)	(.79)	(1.86)	(.60)	(.65)

Note : Maximum is 15 for all RAVLT scores except for the total score out of 75. SEs are presented in parentheses. T1 = trial 1; T5 = trial 5; AI = after interference; DR = delayed recall; DRe = delayed recognition; FP = false positive errors.

the T1 ($t[16] = 1.00$, $p = .332$), T5 ($t[16] = -.64$, $p = .267$), and Total ($t[16] = 0.87$, $p = .199$), trials. AI refers to the number of words recalled from List A after interference from List B. DR refers to the number of words from List A recalled after a 30-min delay. DRe refers to the number of words correctly recognized from List A. The YC group recalled significantly more words than did the NC group, after interference ($t[30] = 3.37$, $p = .001$) and after the 30-min delay ($t[30] = 3.88$, $p = .001$). Relative to the NC group, the YC group also recognized more words ($t[30] = 2.05$, $p = .025$) and made fewer false positive errors ($t[30] = -2.13$, $p = .021$). The NCAD group recalled more words than the AD group after interference ($t[14] = 7.41$, $p = .000$) and after the 30-min delay ($t[14] = 5.96$, $p = .000$). The former also recognized more words ($t[14] = 2.93$, $p = .006$), but did not make fewer false positive errors ($t[14] = -.19$, $p = .428$). There was no significant difference between the NCPD and PD groups in the number of words recalled after interference ($t[16] = 1.04$, $p = .157$) or after the 30-min delay ($t[16] = .38$, $p = .355$). Similarly, both groups recognized a comparable number of words ($t[16] = .00$, $p = 1.00$) and made a similar number of false positive errors ($t[16] = 1.01$, $p = .329$).

Serial Reaction Time task (SRT): Participants made errors naming the location of the asterisk on less than 1% of trials. Trials on which participant or computer errors occurred were excluded from the analyses. Outliers, defined as 3 SDs from the mean location naming latency were removed from the data, for each participant. On average, with errors and outliers removed, 87 trials per block per participant remained for analysis (out of the 100 administered). One AD patient was not capable of performing the task. Data from another AD patient was excluded because the number of trials that could be included in the analyses (~50% for Block 5) was judged insufficient. The average naming latency was calculated for each block for each participant. Naming latency for the final sequence-learning block, Block 4, was compared to that for the random order block, Block 5. Each participant group displayed sequence learning, as indexed by a significantly faster location naming latency for Block 4 relative to Block 5 ($t[15] = -2.38$, $p = .006$ for the YC group; $t[15] = -7.76$, $p < .001$ for the NC group; $t[5] = -2.32$, $p = .034$ for the AD group; and $t[8] = -9.71$, $p < .001$ for the PD group). The means and SEs are illustrated in Figure 1. Repeated-measures ANOVAs confirmed that the difference in naming latency between Block 4 and Block 5, was comparable for the YC and NC groups ($F[1, 30] = .24$, $p = .626$), for the NCAD and AD groups ($F[1, 11] = .19$, $p = .669$), and for the NCPD and PD groups ($F[1, 16] = .14$, $p = .717$).

Mirror Reading: Participant errors and time recording failures occurred on less than 1% of triads. Outliers, defined as 3 SDs from the mean reading latency of each participant, were removed from the data. Three AD patients were not capable of performing the task. Reading latency for Repeat word triads (i.e., those that appeared in every set) was separated from that for Unique word triads (i.e., those that appeared once) in order for repetition priming and skill learning to be analyzed separately.

Repetition Priming: Reading latencies for Repeat word triads are illustrated in Figure 2a. Each group displayed significant repetition priming, as evidenced by shorter reading latencies in Session 3 relative to Session 2 ($t[15] = 3.38$, $p = .002$ for the YC group; $t[15] = 2.97$, $p = .005$ for the NC group; $t[4] = 2.20$, $p = .047$ for the AD group; and $t[8] = 1.98$, $p = .042$ for the PD group) and shorter reading latencies in Session 2 relative to Session 1 ($t[15] = 2.40$, $p = .015$ for the YC group; $t[15] = 5.95$, $p < .001$ for the NC group; $t[4] = 8.78$, $p = .001$for the AD group; and $t[8] = 3.92$, $p = .002$ for the PD group).

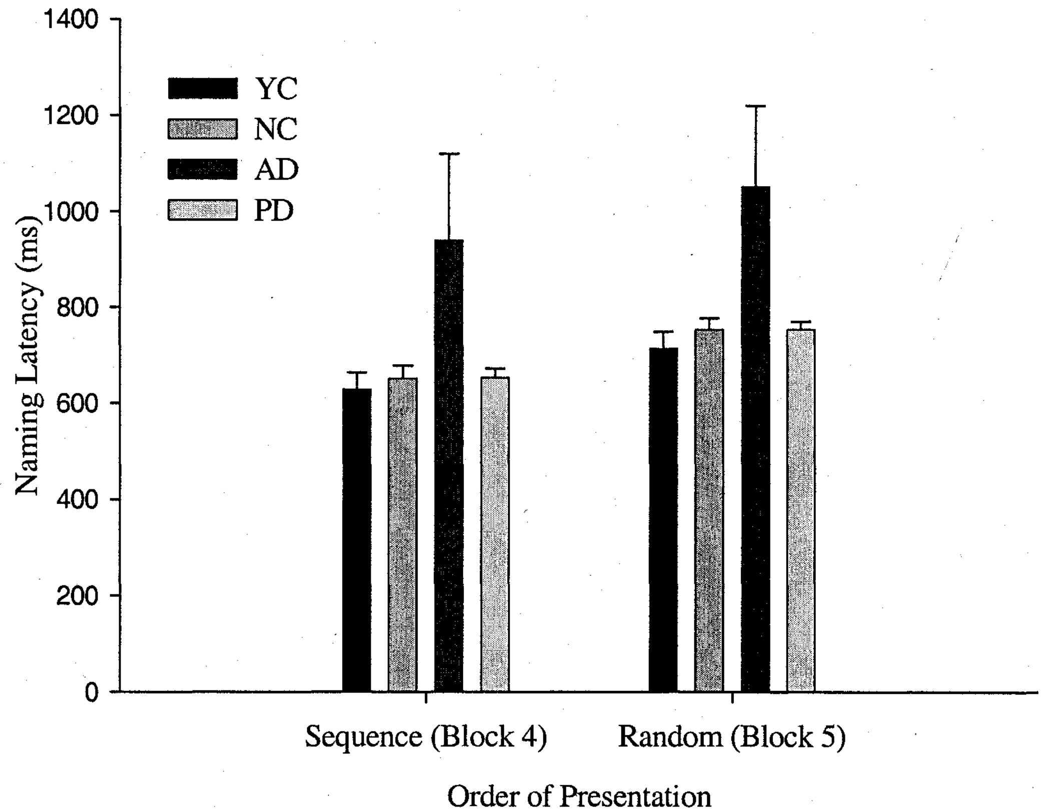


Figure 1. Latency to name the location of the asterisk, in milliseconds, for young and older adults, and for the patient groups, as a function of order of presentation of the asterisk (sequential order versus random order).

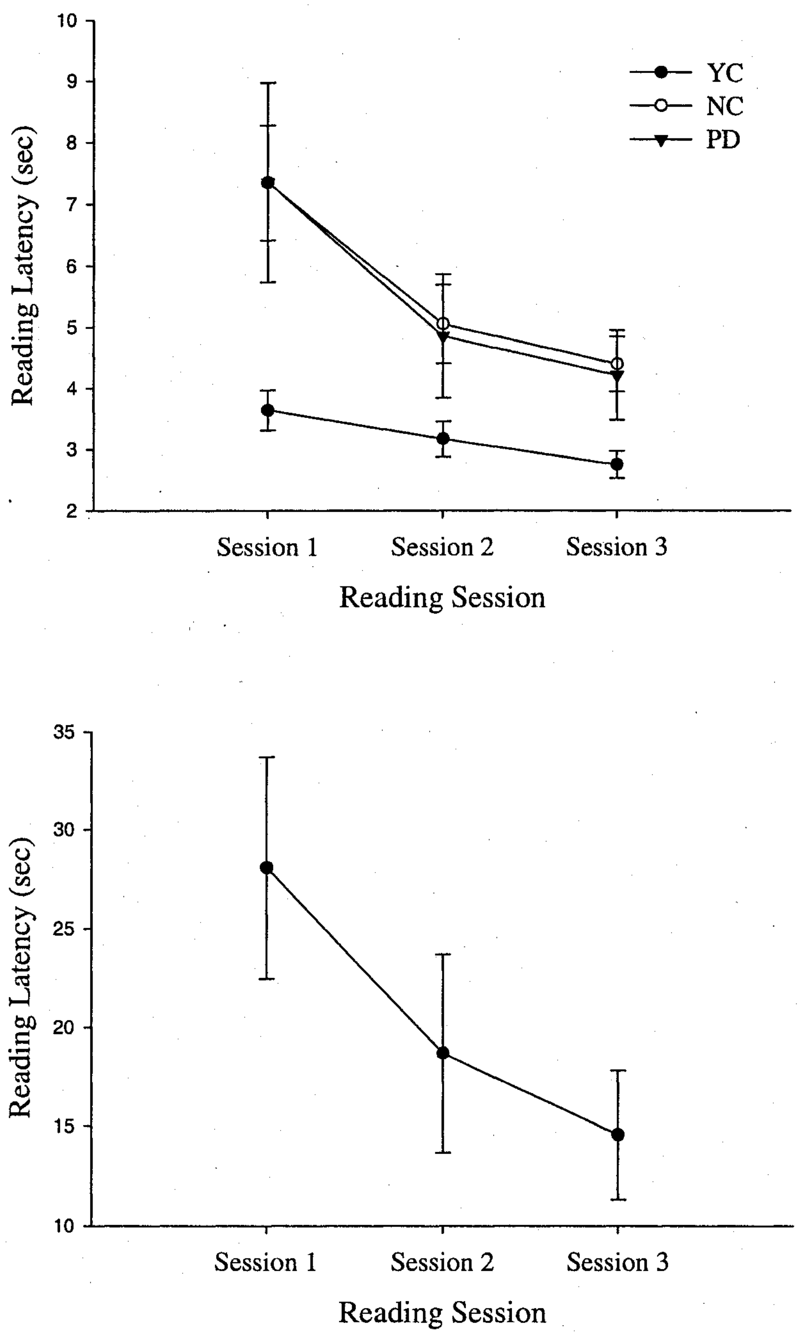


Figure 2a. Reading latency in seconds for repeat words, by reading session, for the YC, NC, and PD groups (top) and the AD group (bottom). Latencies for the AD group are plotted separately because they are longer.

Repeated-measures Group X Session (1, 3) ANOVAs revealed that the effect of repetition on reading latency was larger for the NC than for the YC group ($F[1, 30] = 12.36$, $p = .001$), and larger for the AD than for the NCAD group ($F[1, 11] = 29.59$, $p = .000$). It can be noted that the NC group displayed significantly longer reading latencies than the YC group overall ($F[1, 30] = 11.49$, $p = .002$), as did the AD group relative to its control group, NCAD ($F[1, 11] = 21.23$, $p = .001$). The effect of repetition on reading latency was equivalent for the NCPD and PD groups ($F[1, 16] = .02$, $p = .880$).

Skill Acquisition: Young adults read the new word triads faster in reading session 3 than in reading session 2 ($t[15] = 2.17$, $p = .046$) and faster in reading session 2 than in reading session 1 ($t[15] = 2.41$, $p = .030$). Older adults read the new word triads faster in reading session 2 than in reading session 1 ($t[15] = 3.25$, $p = .005$), but there was no significant difference in the reading latency between sessions 2 and 3 ($t[15] = .24$, $p = .813$). These effects can be observed in Figure 2b. For the AD group, there was no significant difference in reading latency between any of the reading sessions ($t_s[6] = .68$ and .15, $p_s = .526$ and .891, for the comparison of sessions 2 and 3, and sessions 1 and 2, respectively). For the PD group, there was no significant reduction in reading latency between session 2 and 3 ($t[8] = .11$, $p = .919$), but a trend was observed toward a significant reduction in reading latency from reading session 1 to reading session 2 ($t[8] = 2.06$, $p = .074$).

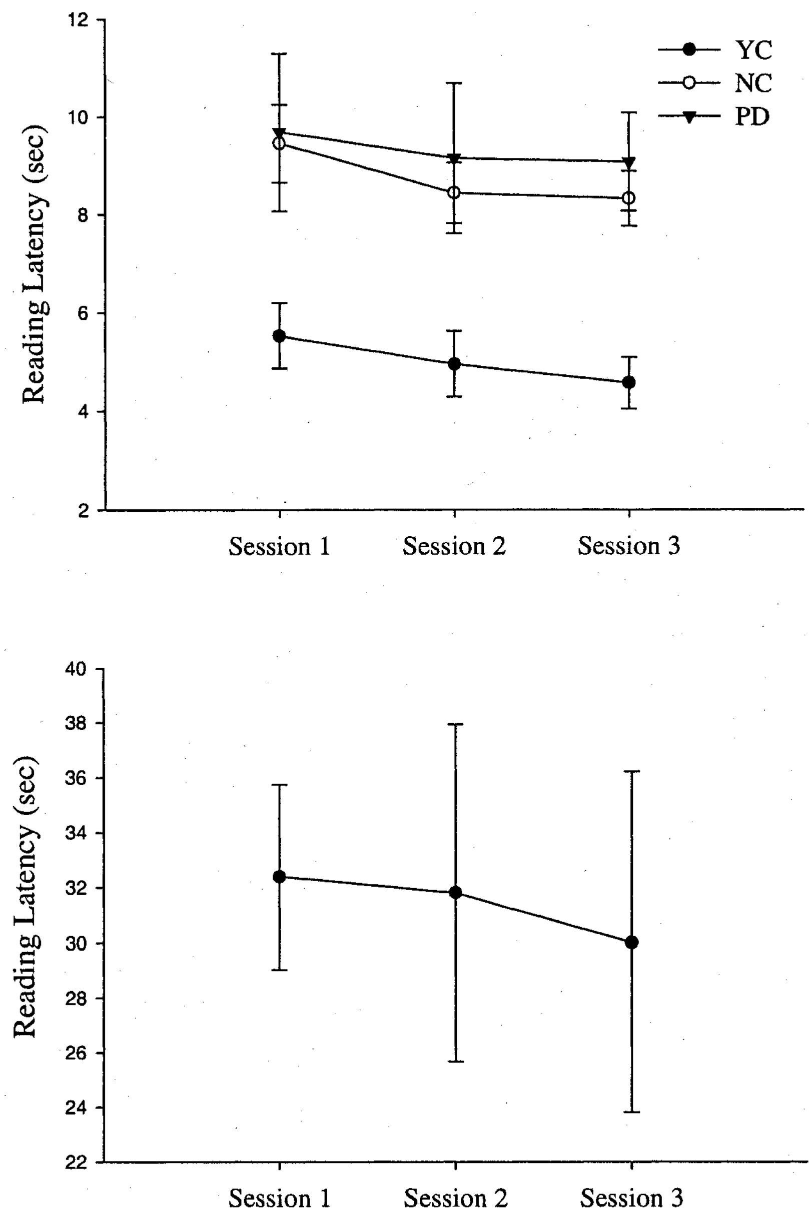


Figure 2b. Reading latency in seconds for new words, by reading session, for the YC, NC, and PD groups (top) and the AD group (bottom). Latencies for the AD group are plotted separately because they are longer.

Language Results

For each measure, results from the NC group were compared to those from the YC group, results from the AD group were compared to those from the NCAD group, and those from the PD group were compared to results from the NCPD group. Repeated-measures ANOVAs were conducted at the .05 significance level with Group as the between-subjects factor and Language as the within-subjects factor. The Least Significant Difference, i.e., no correction, was applied to comparisons across group because of strong apriori hypotheses about group effects. The Bonferroni adjustment was used for post-hoc comparisons across language. Planned comparisons were conducted regardless of the significance of the Group X Language ANOVA interaction effect because the small sample size (bilingual AD and PD patients were very difficult to recruit) lead to reduced power to detect significant interaction effects. Also, given that this is the first exploration of picture description in bilingual AD and PD, avoiding Type II error was at least as much of a concern as avoiding Type I error. The .05 significance level was used, and p-values between .05 and .10 were interpreted as indicative of a trend toward statistical significance.

Word level Measures

Percentage of Unique Words and Unique Nouns: The percent of unique words is presented in Figure 3, for each group within each language. There was no significant main effect of Group ($F[1, 30] = 1.98$, $p = .170$ for the YC-NC comparison; and $F[1, 14] = .06$, $p = .818$ for the NCAD-AD comparison, or of Language ($F[1, 30] < .01$, $p = .939$ for the YC-NC comparison; and $F[1, 14] = 1.72$, $p = .211$ for the NCAD-AD comparison), no significant interaction effect of Group X Language ($F[1, 30] = .38$, p =

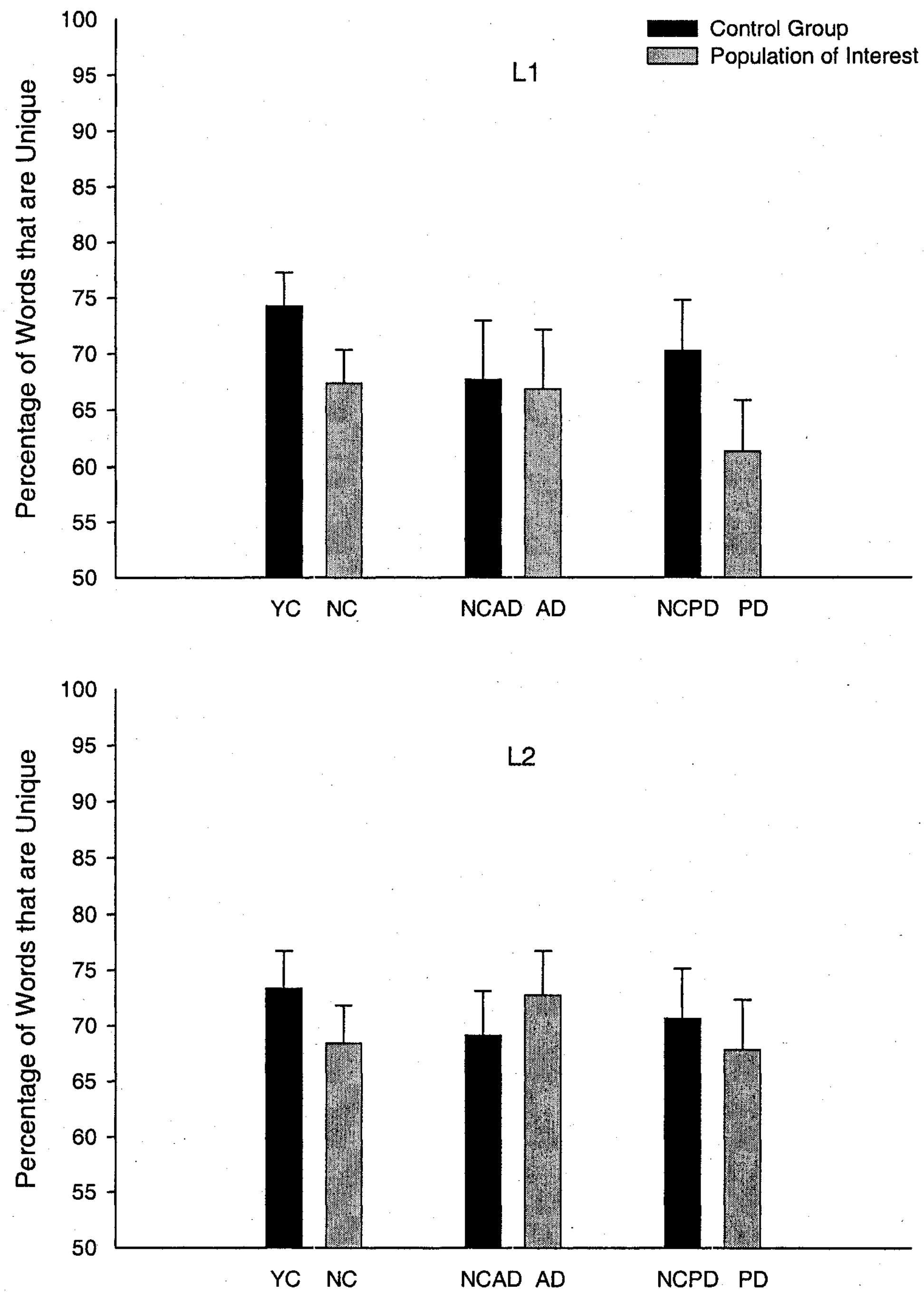


Figure 3. Mean percentage of words that are unique, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

.540 for the YC-NC comparison; and F[1, 14] = .61, p = .446 for the NCAD-AD comparison). Planned comparisons did not yield any significant findings or trend towards significance (p_s > .10). For the NCPD-PD comparison, there was a trend toward a significant main effect of Language (F[1, 14] = 3.78, p = .072), with no significant Group (F[1, 14] = .93, p = .352) or Group X Language effects (F[1, 14] = .2.90, p = .110), and pairwise comparisons indicated that PD patients (p = .022), and not their controls (p = .868), produced more unique words in L2 than in L1.

On average, the percentage of unique nouns was of 78.61, 74.82, 77.08, and 70.59 (SEs = 3.28, 3.28, 5.16, and 5.14), for the YC, NC, AD, and PD group, respectively. None of the group comparisons yielded any significant finding. There were no significant main effect of Group (F[1, 30] = .67, p = .419 for the YC-NC comparison; F[1, 14] = .04, p = .850 for the NCAD-AD comparison; and F[1, 14] = .1.04, p = .325 for the NCPD-PD comparison) or of Language (F[1, 30] = .05, p = .820 for the YC-NC comparison; F[1, 14] = .98, p = .339 for the NCAD-AD comparison; and F[1, 14] = .62, p = .447 for the NCPD-PD comparison), and no significant interaction effect of Group X Language (F[1, 30] < .01, p = .963 for the YC-NC comparison; F[1, 14] = .2.09, p = .170 for the NCAD-AD comparison; and F[1, 14] = 1.11, p = .311 for the NCPD-PD comparison). The planned comparisons did not reveal any significant difference or trend toward a significant difference for any of the groups or language (p_s > .10).

Percentage of Pronouns Relative to Nouns: The percent of pronouns relative to nouns is presented in Figure 4, for each group within each language. For the YC-NC and NCPD-PD comparisons, there were no significant main effect of Group (F[1, 30] = .35, p = .559 for the YC-NC comparison; and F[1, 14] = .64, p = .437 for the NCPD-PD

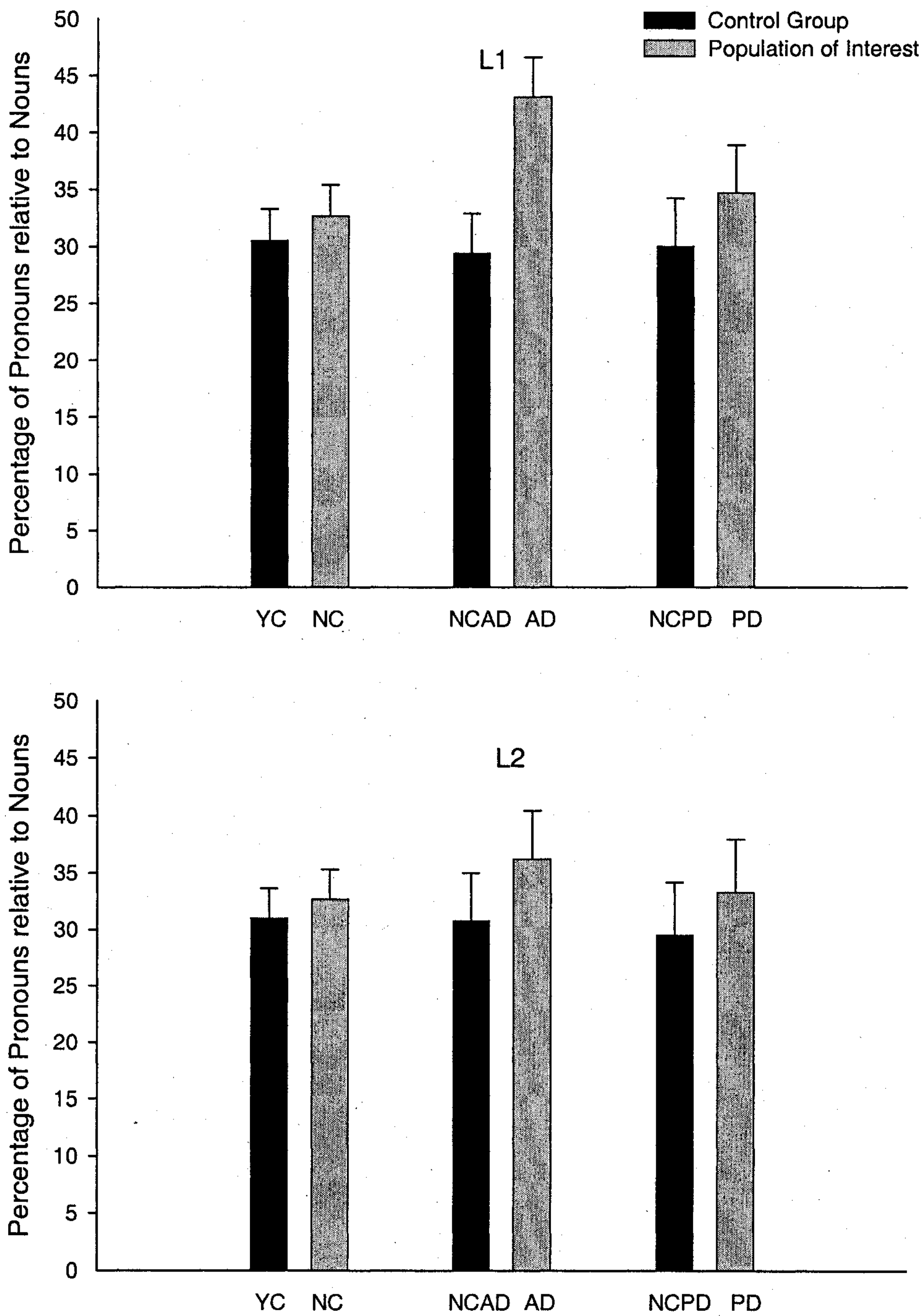


Figure 4. Mean percentage of pronouns, relative to nouns, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

comparison) or of Language ($F[1, 30] = .02$, $p = .900$ for the YC-NC comparison; and $F[1, 14] = .07$, $p = .792$ for the NCPD-PD comparison), and no significant interaction effect of Group X Language ($F[1, 30] = .01$, $p = .910$ for the YC-NC comparison; and $F[1, 14] = .02$, $p = .896$ for the NCPD-PD comparison). Pairwise comparisons did not reveal any significant difference or trend toward a significant difference for any of the groups or language ($p_s > .10$). For the NCAD-AD comparison, there was no main or interaction effect of Language ($F[1, 14] = 1.13$, $p = .306$ for the main effect; and $F[1, 14] = 2.55$, $p = .132$ for the interaction effect). A trend toward a significant main effect of Group was observed ($F[1, 14] = 3.93$, $p = .067$). In L1 ($p = .015$), but not L2 ($p = .377$), AD patients produced a greater percentage of pronouns relative to nouns than did their controls. The AD group generated more pronouns, relative to nouns, in L1 than in L2 ($p = .081$), but this was not a reliable difference for the NCAD group ($p = .711$).

Lexical Errors: The mean percentage of lexical errors relative to the total number of utterances is presented in Figure 5, for each group within each language. The percent of lexical errors was examined relative to all errors, and was examined relative to the number of total utterances. For the YC-NC comparison, there was no main or interaction effect of Group for either of the two measures ($Fs[1, 30] = .01, < .01$, $p_s = .922, .939$ for the main effect; and $F[1, 30] = .16, < .01$, $p = .690, .950$ for the interaction effect, for each measure respectively). For the percentage of lexical errors relative to all errors, a trend was observed for a main effect of Language ($F[1, 30] = 3.67$, $p_s = .065$), with the participants having made fewer lexical errors in L2. This effect of Language was not observed when the number of lexical errors was examined relative to the number of utterances ($F[1, 30] < .01$, $p = .805$). For the patient group ANOVAs, there was no main

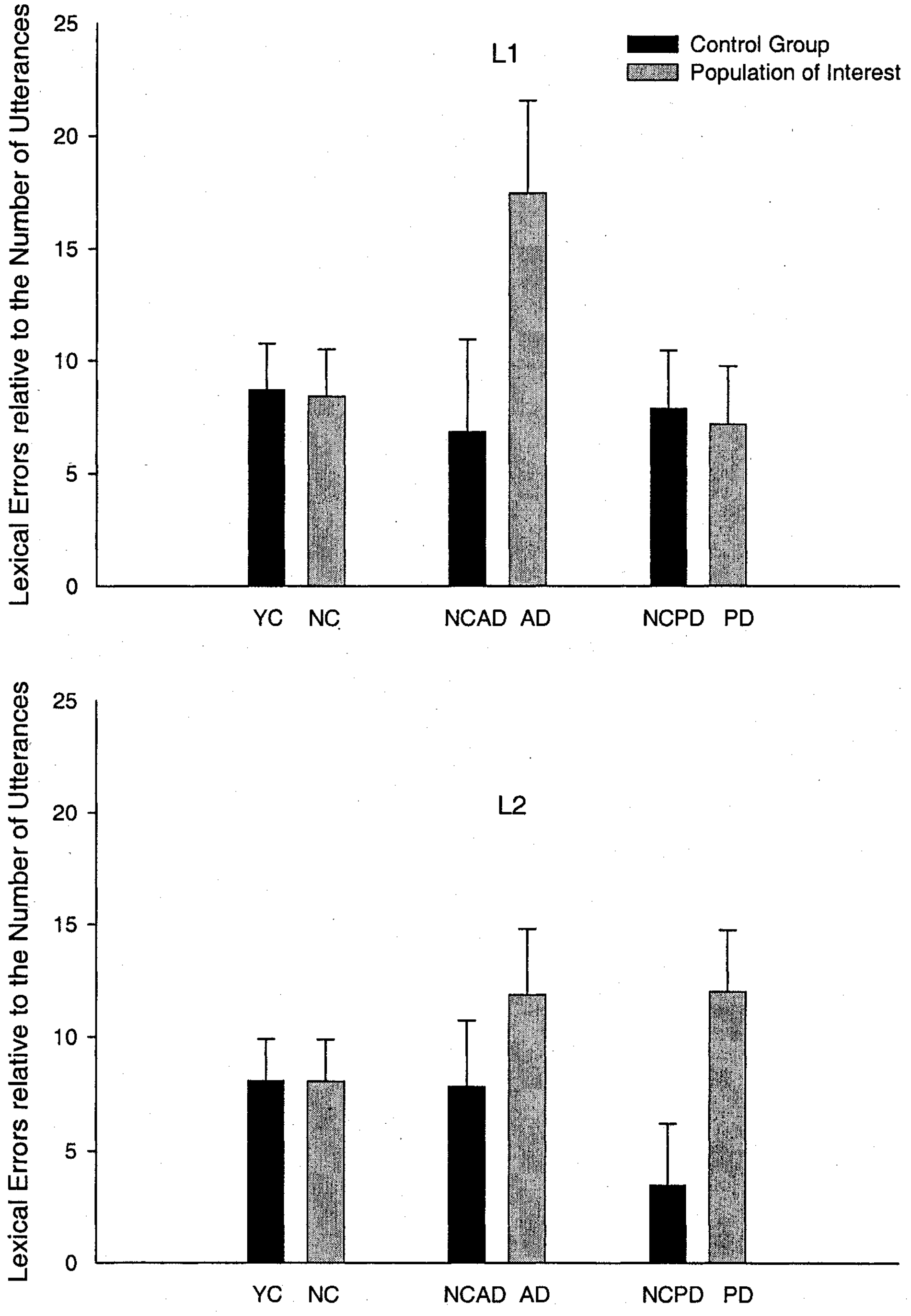


Figure 5. Mean percentage of lexical errors relative to the total number of utterances, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

effect of Group ($F[1, 14] = .54$, $p = .476$ for the NCAD-AD comparison; and $F[1, 14] = .12$, $p = .732$ for the NCPD-PD comparison) or of Language ($F[1, 14] = 1.29$, $p = .275$ for the NCAD-AD comparison; and $F[1, 14] = 1.55$, $p = .234$ for the NCPD-PD comparison), and no significant interaction effect of Group X Language ($F[1, 14] = .26$, $p = .619$ for the NCAD-AD comparison; and $F[1, 14] = 3.07$, $p = .102$ for the NCPD-PD comparison) on the percentage of errors that were of a lexical nature. The pairwise comparisons did not reveal any significant difference or trend toward a significant difference for any of the groups or language ($p_s > .10$). When the number of lexical errors was examined relative to the number of utterances spoken, significant differences emerged. For the NCAD-AD comparison, there was no significant main ($F[1, 14] = .43$, $p = .523$) or interaction effect ($F[1, 14] = .88$, $p = .363$) of Language, but a trend toward a significant main effect of Group was observed ($F[1, 14] = 4.08$, $p = .063$), suggesting that AD patients made more lexical errors per utterance than their healthy counterparts. Pairwise comparisons indicated that this finding reflected a group difference in L1 ($p = .089$) and not L2 ($p = .340$). For the NC-PD comparison, there were no significant main effects of Group ($F[1, 14] = 1.64$, $p = .221$) or of Language ($F[1, 14] = .01$, $p = .914$), but there was a significant Group X Language interaction effect ($F[1, 14] = 4.66$, $p = .049$). In L2 only, PD patients made more lexical errors than their healthy counterparts ($p = .043$; versus $p = .851$ for L1).

Percent of Open-Class Words: The mean percentage of open-class words is presented in Figure 6, for each group within each language. For the YC-NC and NCPD-PD comparisons, there was no significant main effect of Group ($F[1, 30] = .04$, $p = .839$

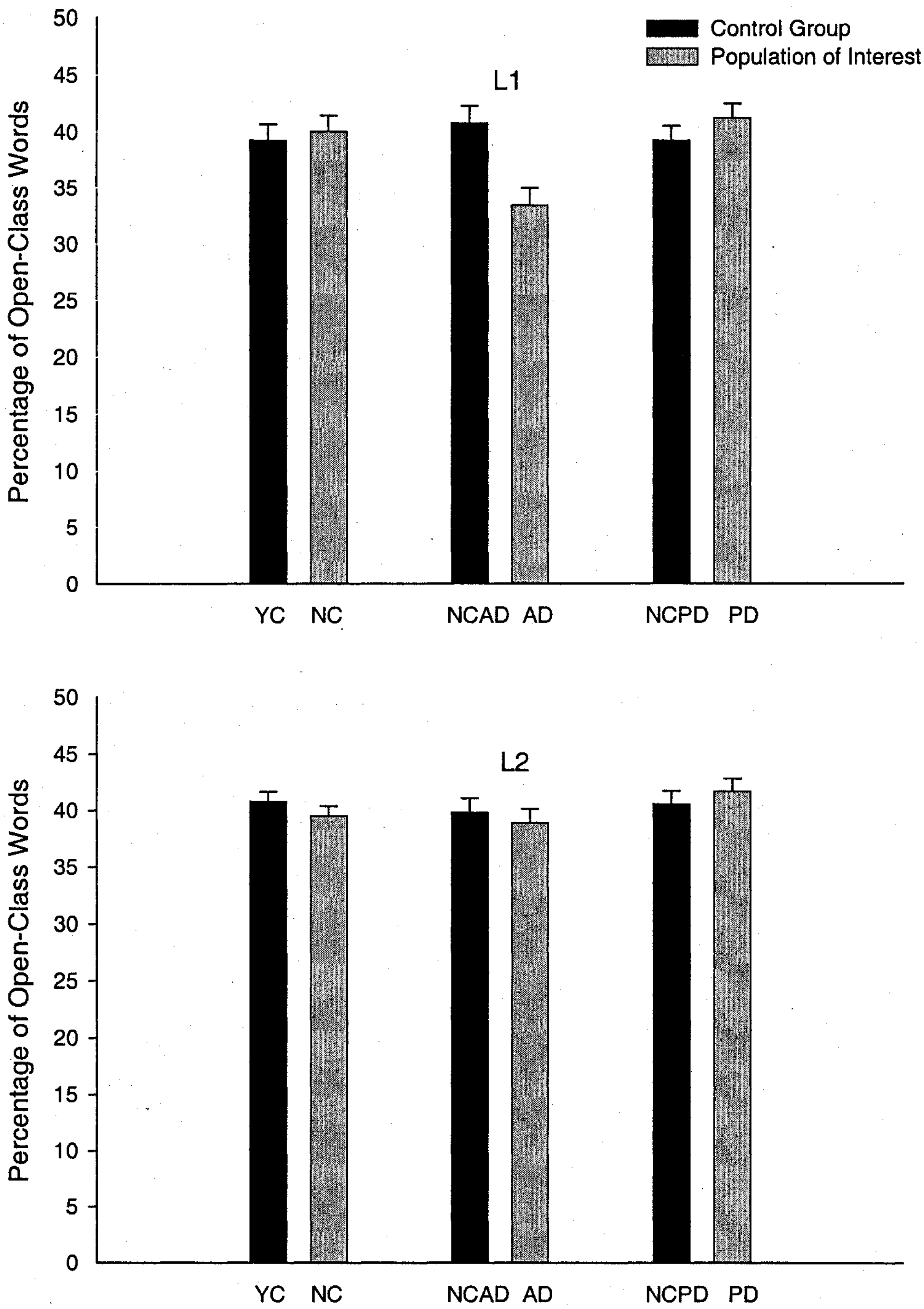


Figure 6. Mean percentage of open-class words, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

for the YC-NC comparison; and $\underline{F}[1, 14] = 1.20$, $\underline{p} = .292$ for the NCPD-PD comparison) or of Language ($\underline{F}[1, 30] = .30$, $\underline{p} = .585$ for the YC-NC comparison; and $\underline{F}[1, 14] = 1.11$, $\underline{p} = .309$ for the NCPD-PD comparison), and no significant interaction effect of Group X Language ($\underline{F}[1, 30] = 1.12$, $\underline{p} = .298$ for the YC-NC comparison; and $\underline{F}[1, 14] = .193$, $\underline{p} = .668$ for the NCPD-PD comparison). The planned comparisons did not reveal any significant difference or trend toward a significant difference for any of the groups or language ($\underline{p}_s > .10$). For the NCAD-AD comparison, there was no significant main effect of Language ($\underline{F}[1, 14] = 2.81$, $\underline{p} = .115$), but a significant main effect of Group was observed ($\underline{F}[1, 14] = 9.05$, $\underline{p} = .009$), moderated by a significant interaction effect of Group X Language ($\underline{F}[1, 14] = 5.35$, $\underline{p} = .036$). In L1 only, the NCAD group produced significantly more open-class words than the AD patients ($\underline{p} = .004$ for L1, $\underline{p} = .603$ for L2). AD patients ($\underline{p} = .014$), and not their controls ($\underline{p} = .661$), produced significantly fewer open-class words in L1 than in L2.

Sentence level Measures

Number of Words per Utterance: No significant effect was found for any of the comparisons: There was no significant main effect of Group ($\underline{F}[1, 30] < .01$, $\underline{p} = .987$; $[1, 14] = .51$, $\underline{p} = .488$; and $[1, 14] = .24$, $\underline{p} = .635$ for the YC-NC, NCAD-AD, and NCPD-PD comparisons, respectively) or of Language ($\underline{F}[1, 30] = 1.10$, $\underline{p} = .303$; $\underline{F}[1, 14] = .85$, $\underline{p} = .372$; and $[1, 14] < .01$, $\underline{p} = .945$ for the YC-NC, NCAD-AD, and NCPD-PD comparisons, respectively), and no significant interaction effect of Group X Language ($\underline{F}[1, 30] = 1.72$, $\underline{p} = .200$; $\underline{F}[1, 14] = .17$, $\underline{p} = .690$; and $\underline{F}[1, 14] = .79$, $\underline{p} = .388$ for the YC-NC, NCAD-AD, and NCPD-PD comparisons, respectively). The planned comparisons did not reveal any significant difference or trend toward a significant difference for any of the groups or language ($p_s > .10$). On average, the YC, NC, AD, and PD group, generated 8.17, 7.62, 7.34, and 7.54 words per utterance in L1 (SEs = 0.53, 0.53, 0.48, and 0.41), and they generated 7.20, 7.73, 6.92, and 7.33 words per utterance in L2 (SEs = 0.23, 0.23, 0.37, and 0.34).

Percent of Utterances that are Subordinates: For each group comparison, there was a significant main effect of Language, with participants having generated more subordinate clauses in L1 than in L2 (F[1, 30] = 9.58, p = .004 for the YC-NC comparison; F[1, 14] = 6.12, p = .027 for the NCAD-AD comparison; and F[1, 14] = 4.38, p = .055 for the NCPD-PD comparison). Again for each group comparison, there was no significant main effect of Group (F[1, 30] = 2.70, p = .111 for the YC-NC comparison; F[1, 14] = .53, p = .478 for the NCAD-AD comparison; and F[1, 14] = .11, p = .744 for the NCPD-PD comparison), or interaction effect of Group X Language (F[1, 30] < .01, p = .936 for the YC-NC comparison; F[1, 14] < .01, p = .995 for the NCAD-AD comparison; F[1, 14] = 1.51, p = .239 for the NCPD-PD comparison). On average, the YC, NC, AD, and PD groups generated 33.16 (SE = 2.98), 27.76 (SE = 2.98), 23.52 (SE = 5.06), and 21.30 (SE = 4.34) subordinate clauses per 100 utterances in L1, respectively, and 26.02 (SE = 2.49), 20.99(SE = 2.49), 14.17(SE = 4.00), and 18.59 (SE = 5.07) subordinate clauses per 100 utterances in L2. Only two of the pairwise comparisons were significant, indicating that language had a significant effect for both young (p = .032) and older adults (p = .041).

Percent of Correct Utterances: The mean percentage of correct utterances is presented in Figure 7, for each group within each language. For the YC-NC comparison, there was no significant effect of Group (F[1, 30] = .05, p = .818 for the main effect, F[1,

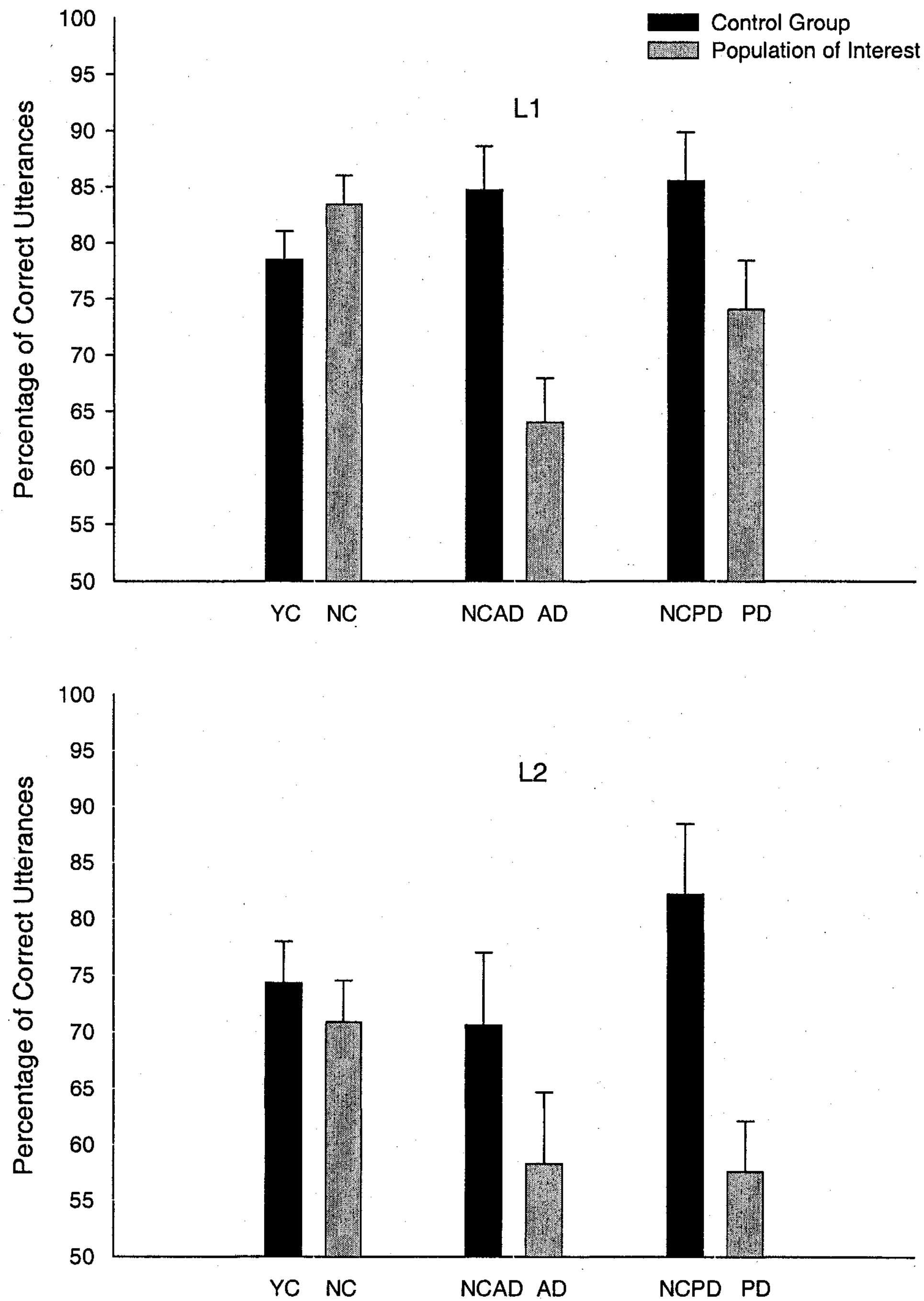


Figure 7. Mean percentage of utterances that were correct, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

30] = 1.84, p = .185 for the interaction effect), but a significant main effect of Language was observed (F[1, 30] = 7.24, p = .012), with the participants having generated more correct utterances in L1 than in L2. Pairwise comparisons indicated this effect was attributable to the older group (p = .008) not the young one (p = .353). For the AD-NCAD comparison, a main effect of Group was obtained (F[1, 14] = 8.54, p = .011), with AD patients having generated fewer correct utterances than their healthy controls. Pairwise comparisons indicated that it is in L1 that the AD group differed from its control group (p = .002), and not in L2 (p = .192). There was no significant interaction effect of Group X Language (F[1, 14] = .727, p = .408). There was a trend toward a significant main effect of Language (F[1, 14] = 4.09, p = .063) suggesting that the NCAD-AD sample, just like the YC-NC one, generated more correct utterances in L1 than in L2. For the NCPD-PD comparison, there was a main effect of Group (F[1, 14] = 8.14, p = .013), with the patient group having generated fewer correct utterances than its control group. Pairwise comparisons indicated that the group effect was significant in L2 (p = .015) and displayed a trend toward significance in L1 (p = .083). A main effect of Language was also observed (F[1, 14] = 5.42, p = .035), with the participants having generated more correct utterances in L1 than in L2, as had been the case for the YC-NC and NCAD-AD comparisons. There was no significant interaction effect of Group X Language (F[1, 14] = 2.41, p = .143).

Grammatical Errors: The mean percentage of grammatical errors relative to the total number of utterances is presented in Figure 8, for each group within each language. The percent of grammatical errors was examined first relative to the total number of errors, and second, relative to the number of utterances produced. For the percent of

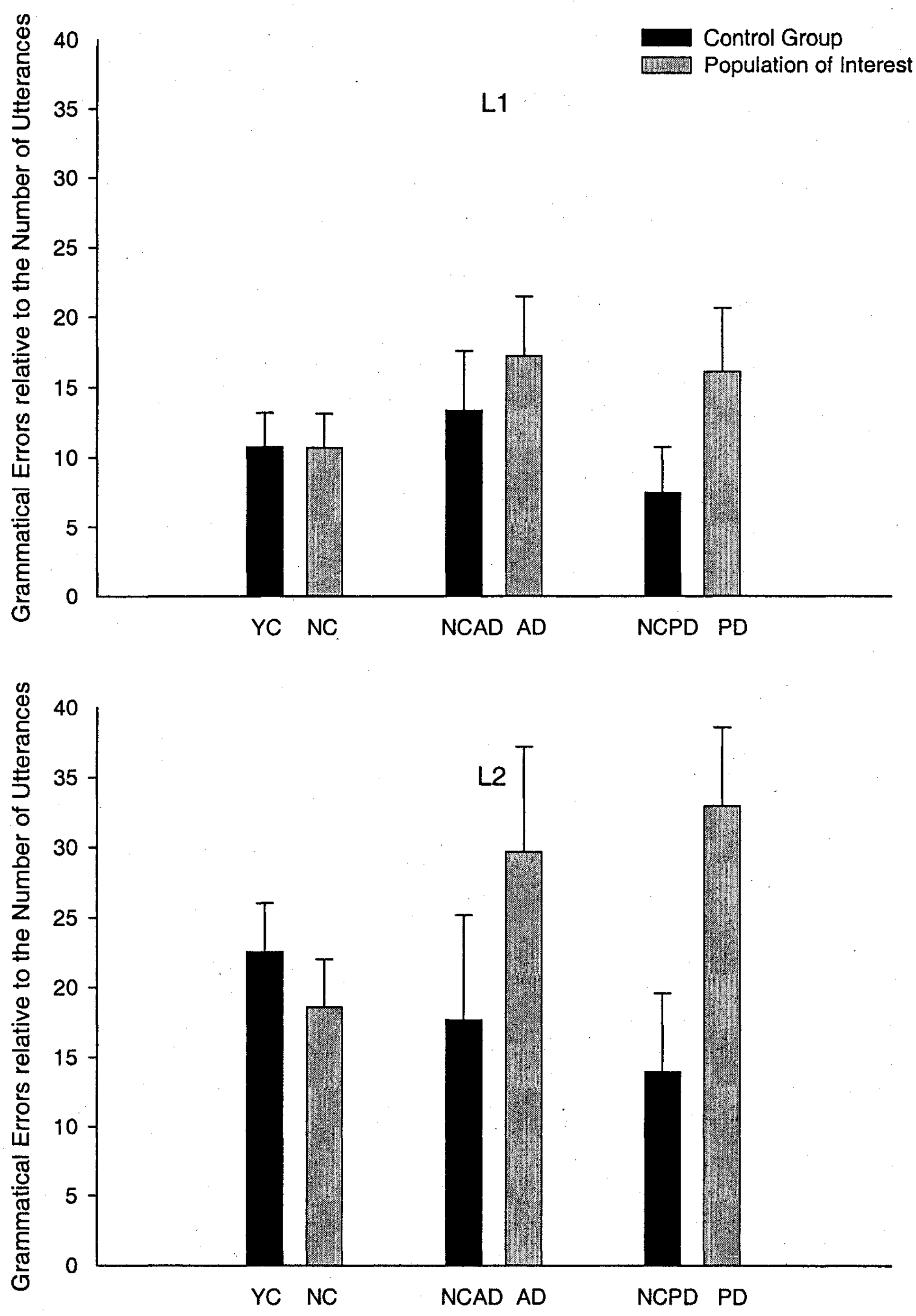


Figure 8. Mean percentage of grammatical errors relative to the total number of utterances, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

grammatical errors relative to total errors, the results from each comparison was similar: There was no main effect of Group ($F[1, 30] = .54$, $p = .470$ for the YC-NC comparison; $F[1, 14] = .20$, $p = .660$ for the NCAD-AD comparison; and $F[1, 14] = .32$, $p = .580$ for the NCPD-PD comparison) and no significant interaction effect of Group X Language ($F[1, 30] < .01$, $p = .967$ for the YC-NC comparison; $F[1, 14] = .16$, $p = .669$ for the NCAD-AD comparison; and $F[1, 14] = .18$, $p = .680$), but a main effect or trend towards a main effect of Language ($F[1, 30] = 5.99$, $p = .020$ for the YC-NC comparison; $F[1, 14] = 4.00$, $p = .065$ for the NCAD-AD comparison; and $F[1, 14] = 13.88$, $p = .002$ for the NCPD-PD comparison), with participants having made more grammatical errors in L2 than in L1. For the YC-NC sample, pairwise comparisons confirmed that there was a trend toward an effect of Language for the young ($p = .089$) and older ($p = .099$) group alike, and for the NCPD ($p = .011$) and PD ($p = .035$) groups. For the number of grammatical errors relative to the number of utterances, results are presented in Figure 6. A significant main effect of Language was found for the YC-NC comparison ($F[1, 14] = 15.72$, $p = .000$), with again, more grammatical errors in L2 than in L1. Pairwise comparisons indicated that this finding was true for the young ($p = .002$) and older ($p = .032$) samples. There was no significant main or interaction effect of Group ($F[1, 14] = .36$, $p = .554$ for the main effect; and $F[1, 14] = .62$, $p = .436$ for the interaction effect). For the NCAD-AD comparison, there was no significant main or interaction effect of Group ($F[1, 14] = 1.68$, $p = .251$ for the main effect; and $F[1, 14] = .45$, $p = .513$ for the interaction effect) and no significant main effect of Language ($F[1, 14] = 1.94$, $p = .185$). The planned comparisons did not yield any significant result ($p_s > .10$). For the NCPD-PD comparison, there was a significant main effect of Group (($F[1, 14] = 7.69$, p =

.015), with PD patients having made more grammatical errors than their controls, and a significant main effect of Language ($\underline{F}[1, 14] = 7.74$, $\underline{p} = .015$), with the NCPD-PD sample having made more grammatical errors in L2 than in L1. Planned comparisons indicated that this effect was attributable to the PD group ($\underline{p} = .013$), not the NCPD group ($\underline{p} = .293$). There was no significant interaction effect of Group X Language ($\underline{F}[1, 14] = 1.53$, $\underline{p} = .236$), and the planned comparisons suggested that the Group effect was present in L1 ($\underline{p} = .081$) and L2 ($\underline{p} = .032$).

Discourse level Measures

Number of Information Units: The average number of information units is presented in Figure 9, for each group within each language. For the YC-NC and NCPD-PD comparisons, there were no significant main effect of Group ($\underline{F}[1, 30] = 2.06$, $\underline{p} = .162$, and $\underline{F}[1, 14] = 1.91$, $\underline{p} = .189$, respectively) or of Language ($\underline{F}[1, 30] = .40$, $\underline{p} = .532$, and $\underline{F}[1, 14] = .65$, $\underline{p} = .433$, respectively), and no significant interaction effect of Group X Language ($\underline{F}[1, 30] < .01$, $\underline{p} = .944$, and $\underline{F}[1, 14] = .37$, $\underline{p} = .554$, respectively). The planned comparisons did not reveal any significant difference for any of the groups or language ($\underline{p}_s > .10$). For the NCAD-AD comparison, there was no significant main or interaction effect of Language ($\underline{F}[1, 14] = .22$, $\underline{p} = .644$ for the main effect; and $\underline{F}[1, 14] = .14$, $\underline{p} = .711$ for the interaction effect). A significant main effect of Group was observed ($\underline{F}[1, 14] = 8.93$, $\underline{p} = .010$), with AD patients having generated fewer information units than their healthy counterparts. Planned comparisons showed this to be true in both L1 and L2 ($\underline{p}_s = .012$ and $.016$, respectively).

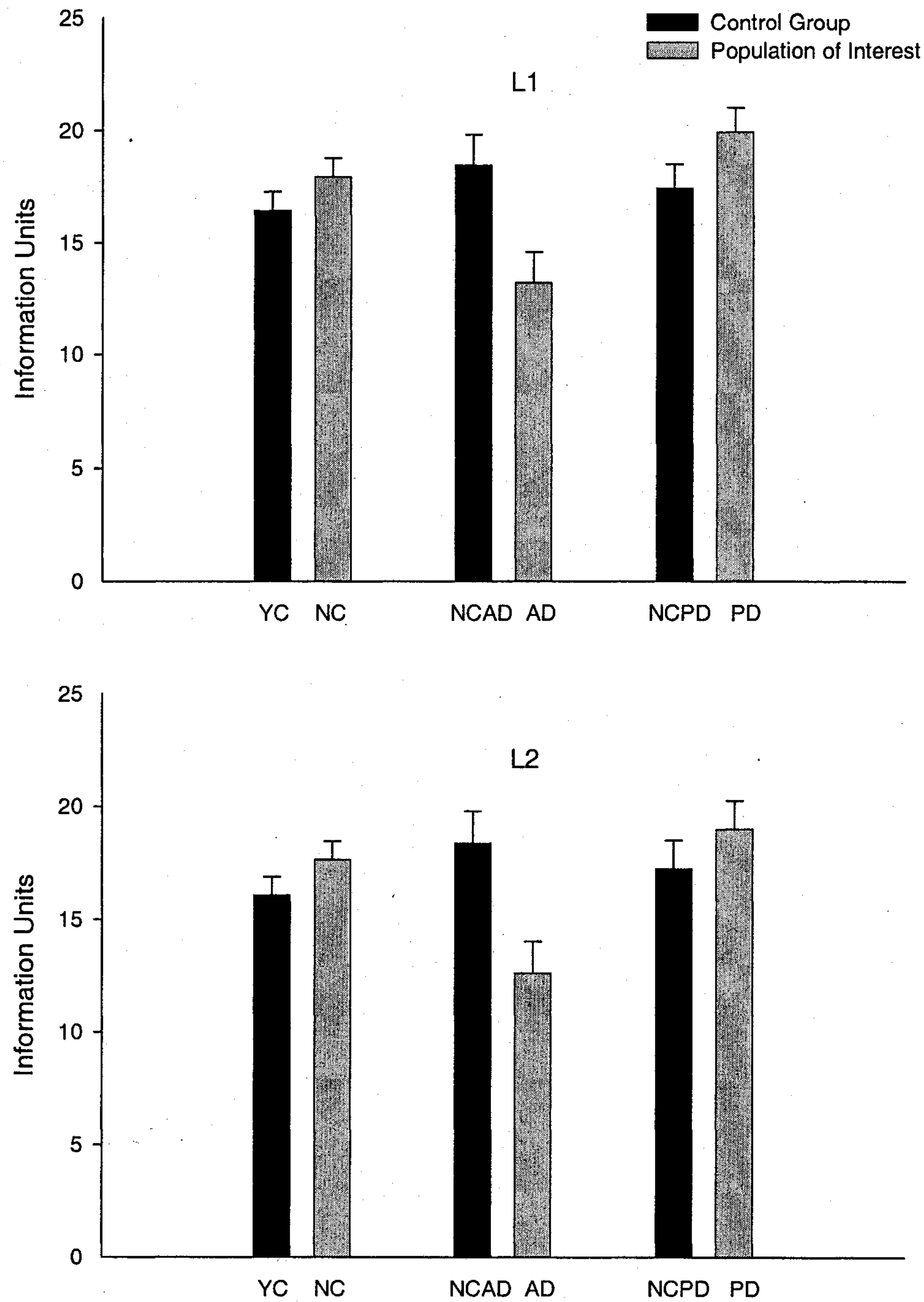


Figure 9. Number of information units (max = 25), for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

Total Number of Utterances: The number of utterances spoken on average is presented in Figure 10, for each group within each language. For the YC-NC and NCPD-PD comparisons, there were no significant main effect of Group ($F[1, 30] = 2.60$, $p = .117$, and $F[1, 14] = 2.08$, $p = .172$, respectively) or of Language ($F[1, 30] = .96$, $p = .335$, and $F[1, 14] = 1.81$, $p = .200$, respectively), and no significant interaction effect of Group X Language ($F[1, 30] = 1.53$, $p = .225$, and $F[1, 14] = 1.22$, $p = .288$, respectively) on the number of utterances spoken. The planned comparisons did not reveal any significant difference for any of the groups or language ($p_s > .10$). For the NCAD-AD comparison, there were also no significant main effect of Group ($F[1, 14] = .43$, $p = .524$) or of Language ($F[1, 14] = 3.03$, $p = .104$), and no significant interaction effect of Group X Language ($F[1, 14] = .67$, $p = .426$), but pairwise comparisons revealed a trend for the AD group to have produced more utterances in L1 than in L2 ($p = .092$).

Total Number of Words: The number of words spoken on average is presented in Figure 11, for each group within each language. For the YC-NC and NCPD-PD comparisons, there were no significant main effect of Group ($F[1, 30] = 2.64$, $p = .115$, and $F[1, 14] = 1.19$, $p = .294$, respectively) or of Language ($F[1, 30] = 2.82$, $p = .104$, and $F[1, 14] = 2.59$, $p = .130$, respectively), no significant interaction effect of Group X Language ($F[1, 30] = 1.38$, $p = .250$, and $F[1, 14] = 2.00$, $p = .180$, respectively). Planned comparisons revealed that older adults ($p = .053$), and not younger ones ($p = .724$), tended to speak more in L1 than in L2, as did PD patients ($p = .022$). For the NCAD-AD comparison, no significant effect of Group was observed ($F[1, 14] = .75$, $p =$

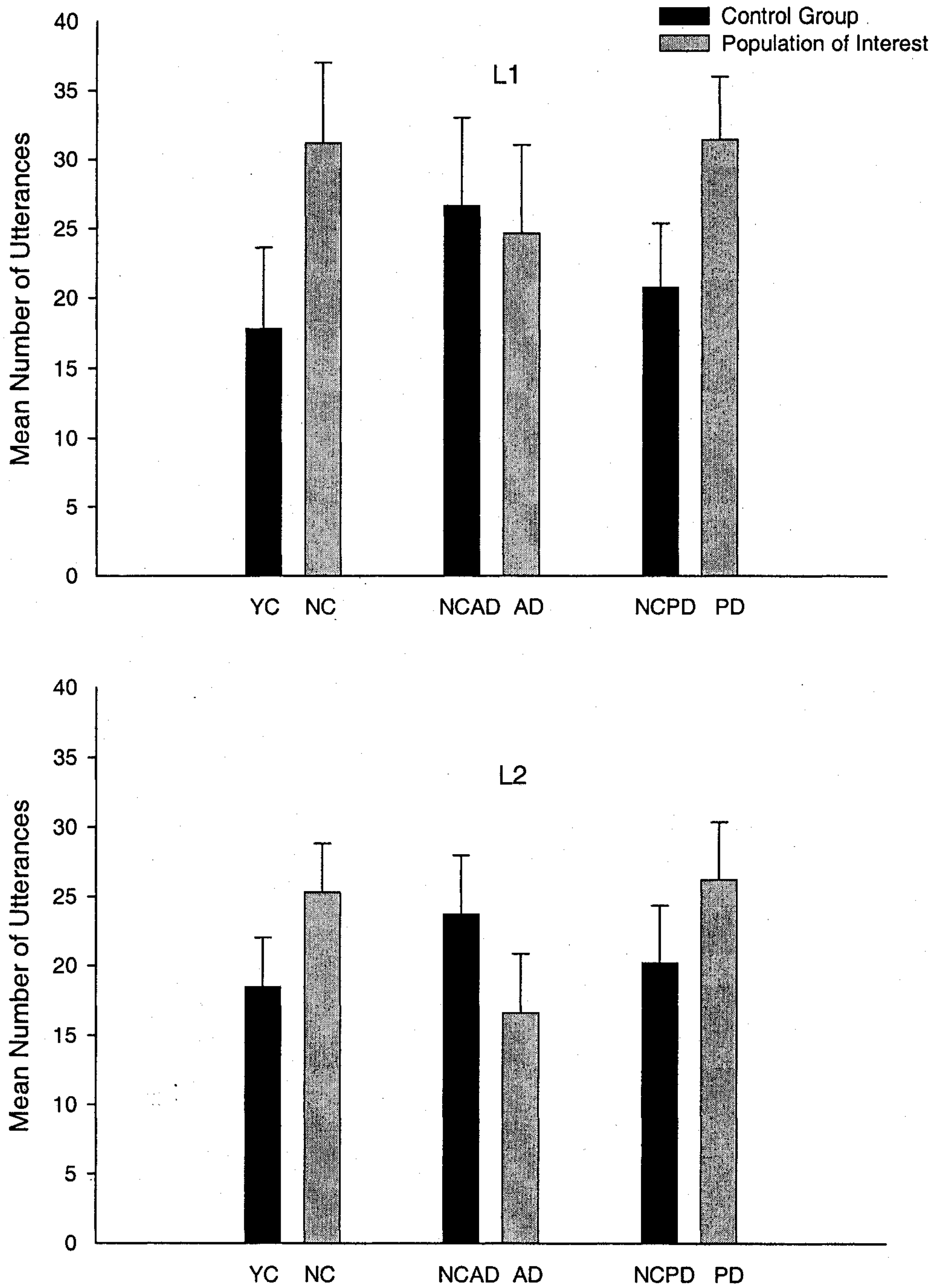


Figure 10. Mean number of utterances spoken, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

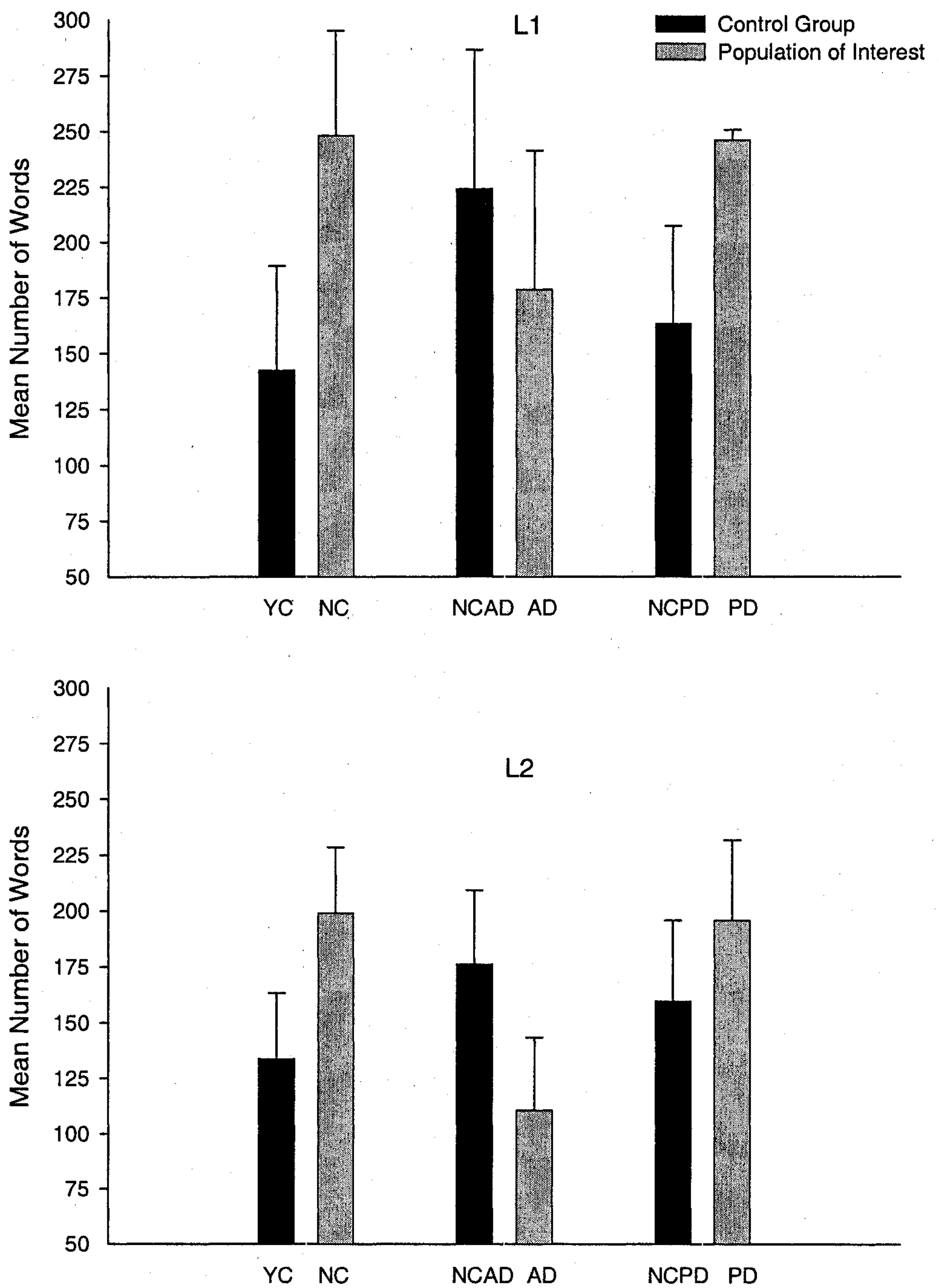


Figure 11. Mean number of words spoken, for each comparison, in L1 (top panel) and L2 (bottom panel). Aging refers to the YC-NC comparison, AD to the NCAD-AD comparison, and PD to the NCPD-PD comparison. Error bars represent SEs.

.402 for the main effect, and F[1, 14] = .13, p = .729 for the interaction effect), but a trend toward a significant main effect of Language was found (F[1, 14] = 4.09, p = .063), with the NCAD-AD sample having spoken more words in L1 than in L2. Planned comparisons did not provide additional findings ($p_s > .10$).

Summary: The results are summarized in Table 4. Young and older adults did not differ on any of the measures. However, only older adults, and not younger ones, tended to have produced more correct utterances and to have spoken more words in L1 than in L2. AD patients produced more pronouns, made more lexical errors, and used fewer open-class words than their controls in L1. The speech samples of AD patients contained fewer information units than those of the NCAD group in L1 and L2. AD patients, and not their controls, tended to have produced more utterances in L1 than in L2. PD patients made more lexical errors in L2 than their controls. They generated fewer correct utterances and made more grammatical errors than their healthy counterparts in L1 and L2. PD patients, and not their controls, generated more correct utterances, made fewer grammatical errors, and tended to have spoken more, in L1 than in L2. PD patients, and not their healthy counterparts, generated fewer unique words in L1 than in L2.

Table 4. *Summary of Significant Findings and Statistical Trends for Each Comparison, for the Speech Measures on which Significant Differences were Observed.*

	YC-NC	NCAD-AD	NCPD-PD
Unique Words			L2 > L1 ~ L2 > L1 in PD group*
Pronoun Use		L1> L2 in AD group~ AD > NCAD in L1*	
Lexical Errors	L1 > L2 ~	AD > NCAD in L1~	PD > NCPD in L2*
Open-class Words		L2 >L1 in AD group* NCAD > AD in L1*	
Subordinate Clauses	L1 > L2*	L1 > L2*	L1 > L2 ~
Correct Utterances	L1> L2 in NC group*	L1 > L2~ NCAD > AD in L1*	L1 > L2* NCPD > PD in L1~ NCPD > PD in L2*
Grammatical Errors	L2 > L1*	L2 > L1 ~	L2 > L1 PD > NCPD in L1~ PD > NCPD in L2*
Information Units		NCAD > AD in L1* NCAD > AD in L2*	
Total Number of Words	L1> L2 in NC group~	L1 > L2 ~	L1 > L2 in PD group*

Note: * = statistically significant finding ($p < .05$)
~ = statistical trend toward significance ($p < .10$)

Discussion

Paradis (1994, 2004) and Ullman (2001) were the first to postulate precise links between memory and language in bilinguals, leading to specific predictions for language deterioration in bilingual dementia and PD. They argued that whereas L1 grammar relies on procedural memory, L2 grammar, when learned after puberty in a formal setting, relies more on declarative memory. The lexicon of any language is assumed to depend on declarative memory. Given these assumptions, AD, which affects mostly declarative memory, was expected to affect L2 grammar and the lexicon, and PD, which affects predominantly procedural memory, was expected to affect L1 grammar. Healthy aging, which relatively spares semantic memory and procedural memory, but affects episodic memory, was expected to minimally affect the lexicon and grammar in L1 and L2.

Results from the patient groups in L1 provide support for the greater involvement of declarative memory in supporting the lexicon, and for procedural memory playing a greater role in grammar, as determined from the observation of evidence of lexical difficulties in the AD group, with relative sparing of grammar, and greater evidence of grammatical than lexical difficulties in the PD group. However, AD patients appeared more impaired in L1 than in L2, and the PD patients equally impaired in L1 and L2, which does not support the position that L1 grammar is dependent upon procedural memory and L2 grammar upon declarative memory. Results are discussed separately for the effects of aging, AD, and PD. The memory and language performance of each group is discussed, followed by a general discussion of the implications and limitations of the findings, and of future directions.

Memory and Language in Healthy Aging

The BEM and RAVLT recruit episodic aspects of declarative memory, since individuals must remember the stimuli presented during the learning episode. As expected, given that episodic memory decreases with aging (Flicker et al., 1986), older adults remembered fewer designs and words than did younger adults, on the BEM and RAVLT, respectively. By contrast, aging had no effect on procedural memory, as shown by the fact that the older group performed similarly to the younger group on the SRT and mirror-reading tasks. For each group, performance on these two tests improved with repetition. This finding is consistent with procedural memory being relatively immune to aging (Smith & Fullerton, 1981). The magnitude of the repetition priming effect on the mirror-reading task was larger for older adults than for younger ones. Similar age-related increases in priming effects in the literature have been attributed to the fact that populations with longer reaction times can benefit more from priming (Giffard, Desgranges, Kerrouche, Piolino, & Eustache, 2003). Since the older group displayed significantly longer reading latencies than the younger one on the mirror-reading task, it is likely that the observation of greater repetition priming in older adults is a consequence of slower reading speed. In sum, the older group displayed intact procedural memory and a reduction in episodic memory, relative to the younger group, as predicted.

As expected, there was no effect of age on any of the lexical measures of picture description. Older and younger adults produced a comparable percentage of unique words, of unique nouns, and of open-class words, in L1 and in L2. Both groups used a similar percentage of pronouns to refer to the people, objects, or places in the picture. These findings provide evidence that aging does not affect lexical ability in picture description. The older and younger group displayed a tendency to make more naming errors in L1 than in L2, based on a statistical trend. There are at least three possible explanations for this: 1) This finding may reflect the fact that most young participants were native speakers of French studying full-time at an English university. Lexical items in L2 may have had a lower threshold of activation than lexical items in L1 because of recent use. 2) Since 26 of the 32 healthy participants were French-L1, the greater rate of lexical errors in L1 relative to L2 may be a language-specific effect. It may be that Quebecois-French allows for certain words to be used to refer to objects that are not correct based on the dictionary definition of the word, but that are nevertheless used with relatively high frequency. For instance, a stool ("tabouret") is not a bench ("banc"), but in Quebecois-French calling the stool a "petit banc" may be somewhat acceptable. In other words, a word coded as a lexical error in English (e.g., using the word "bench" for "stool") may have a frequency of occurrence of 1% in a healthy sample, but the same coded error in French (e.g., using the words "petit banc" for "tabouret") may have a frequency of occurrence of 10%. 3) The L2 lexicon may contain fewer items than the L1 lexicon, and consequently, the retrieval of items from the L2 lexicon may require fewer inhibitory resources than would the retrieval of lexical items from the larger L1 lexicon (i.e., fewer lexical associates need to be inhibited).

The performance of the young and older group on the grammatical measures, of words per utterance and percentage of subordinate clauses, was comparable. Both groups generated utterances that contained seven to eight words, on average, in L1 and in L2. An effect of language was observed for the number of subordinate clauses produced, relative to the total number of utterances, as each participant group produced more subordinate clauses in L1 than in L2. With French as the L1 for thirteen of the sixteen participants in each group, this finding may reflect a language-specific effect, with the French sentences being more likely to contain a subordinate clause, perhaps. Alternatively, this finding, together with the fact that each group made more grammatical errors in L2 than in L1, may indicate that the healthy participants, despite reporting feeling equally or almost equally comfortable in English and French, were nevertheless L1-dominant at the level of the grammar (i.e., they had not attained equal proficiency). This may have been particularly true of the older group, who tended to talk more in the L1 task than in the L2 task and to produce more correct utterances in L1 than in L2, findings which were not observed in the younger cohort. Alternatively, if these later two findings are replicated in future studies, they may suggest that aging has a greater impact on an L2 than an L1. This would support the position that declarative memory, which is not immune to the effects of aging, plays a larger role in L2 grammar than in L1 grammar, although aging has been shown to affect mostly the episodic aspects of declarative memory and not the semantic aspects, which are the ones more likely to be linked with language. As expected, the picture descriptions of older adults were just as informative as those of younger adults, and contained a comparable number of utterances, in each language.

In summary, the performance of the older adults did not differ substantially from that of the younger cohort. The only differences were that older adults, and not younger ones, tended to talk more and produced a greater percentage of correct utterances in L1 than in L2. This finding may indicate the older adults were L1-dominant at the level of the grammar (i.e., may not have reached equal proficiency in L1 and L2), or could suggest that aging has a greater impact on L2 grammar than on L1 grammar.

Memory and Language in AD

As expected given that declarative memory deficits are a hallmark of AD, the AD group displayed clear deficits on the tests of declarative memory. AD patients were not able to learn a list of simple common words, or to recognize these words, as well as healthy age-matched controls were, on the RAVLT. The patient group was also impaired in the visual modality, as they recognized significantly fewer designs than their controls. By contrast, AD patients were able to benefit as much as their healthy counterparts from repetition on the SRT and mirror-reading task. The magnitude of the repetition priming effect on the mirror-reading task was larger for the AD patients than for the NCAD group. This is analogous to how the magnitude of the same effect was greater for the older group relative to the younger one, and is similarly attributable to the fact that AD patients displayed longer reading latencies than their controls overall. Whereas as a group, the AD patients who completed the tests displayed procedural learning, one of the AD patients was unable to complete the SRT and three were unable to complete the mirror-reading task. To perform on the SRT, the participant must be able to remember four locations and understand that the task is to name the location where the asterisk appears. The patient who did not complete the test was unable to understand and remember the instructions. To succeed on the mirror-reading task, the participant has to identify the letters, combine them, and retrieve from lexical memory an entry that matches the visual input. To avoid a ceiling effect in the control groups, the mirror-reading words were selected to be of low frequency. The three patients unable to perform the task appeared unable to retrieve these words from lexical memory. We are nevertheless confident, based on the group results for the SRT and mirror-reading of repeat words, that the AD patients had intact procedural memory and that those who failed to complete the tasks appeared to do so because of working memory and lexical memory limitations and not because of procedural memory restrictions. The AD group did not learn to read words printed backwards significantly faster with practice, but this may be related to the high variability in the performance of the patients, as can be seen in Figure 2b on page 65. In sum, the memory findings for AD patients are indicative overall of good procedural memory and of declarative memory deficits, suggesting impairments in medial temporal lobe function with relative sparing of the basal-ganglia circuitry.

Based on the argument that declarative memory is associated with the lexicon and L2 grammar, and given their clear display of declarative memory deficits, AD patients were expected to be impaired on the lexical measures, equally so in L1 and L2, and on the grammatical or sentence level measures more so in L2 than in L1. There were five lexical measures: The percent of unique nouns, of unique words, of pronouns, of lexical errors, and of open-class words. Results for L1 are discussed first. AD patients did not differ from healthy older adults on the percentage of unique nouns and unique words generated. However, relative to their healthy counterparts, the patient group used more pronouns, a finding which converges with those reported in the literature on pronoun use in AD (see Almor et al., 1999). The AD group made more lexical errors than their controls, replicating similar observations in the literature (Kave & Levy, 2003; McNamara, Obler, Au, Durso, & Albert, 1992). AD patients produced fewer open-class words than their controls, in accordance with reports of AD-related impairments in the use of open-class words (Hier et al., 1985; Nicholas et al., 1985). In sum, the picture descriptions of AD patients, relative to those of healthy older adults, incorporated more pronouns, more lexical errors, and fewer open-class words, in L1. The documentation of lexical impairments in AD concords with a substantial body of evidence (Appell et al., 1982; Huff et al., 1986; Martin & Fedio, 1983; Nicholas et al., 1996), and supports the link between declarative memory and the lexicon.

Results from the language comparisons suggest that AD has a greater impact on lexical processing in L1 than in L2, since the AD patients evidenced lexical difficulties on three measures in L1, but did not differ from their controls on any of the lexical measures in L2. These findings do not converge with those from De Piciotto and Friedland (2001) or Meguro et al. (2003). De Piciotto and Friedland (2001) reported that AD patients generated more words in L1 than in L2 on a semantic fluency task, although this effect was not statistically tested, and Meguro et al. (2003) observed that AD patients were more impaired for irregularly spelled words than for regular words in both L1 and L2. The observation of greater lexical impairment in L1 than in L2 in the present study appears discrepant with the view that the lexicon is dependent upon declarative memory in any language. A useful distinction is between neurolinguistic representations and psycholinguistic processes. Neurolinguistically, words are stored in temporo-parietal cortex, which is part of the neural substrate of the declarative memory system, and there is no clear evidence that L1 and L2 words are stored in separate substrates (see Abutalebi, Cappa, & Perani, 2005, for a review). Psycholinguistically, exactly how language-specific lexical items are retrieved from the bilingual lexicon remains to be fully understood, but there is evidence that L1 and L2 words are processed differently (see

Kroll & Tokowicz, 2005 for a review). For many bilinguals, the L2 lexicon may contain fewer items than the L1 lexicon. When a lexical item is retrieved (e.g., "stool"), lexical associates may need to be inhibited (e.g., "chair", "seat"). If the L2 lexicon is smaller, the retrieval of items from that lexicon may require fewer inhibitory resources than would the retrieval of lexical items from the larger L1 lexicon. As inhibitory resources may be lower in AD (e.g., Grossman, Smith, Koenig, Glosser, Rhee, & Dennis, 2003), patients may perform better on lexical measures in L2 than in L1, because there are fewer lexical associates to inhibit. As such, AD patients would be less prone to make lexical errors or to use more pronouns and fewer open-class words in L2 than in L1, relative to healthy older adults. Lexical deficits would consequently be readily observable in L1 but not L2.

At the sentence level, four measures were selected: The number of words per utterance, the percentage of subordinate clauses, the percent of correct utterances, and the percent of grammatical errors. Results for L1 are discussed first. The utterances of AD patients contained as many words as did those from healthy controls. The performance of the AD group was comparable to that of the healthy group for the percent of subordinate clauses and of grammatical errors, with both groups having produced more subordinate clauses and fewer grammatical errors in L1 than in L2. This finding is likely attributable to lower proficiency in L2 than in L1, and not to aging and AD affecting L2 grammar more than L1 grammar, since the young participants displayed these same effects. In contrast, the AD group generated fewer correct L1 utterances than healthy older adults, a global measure which reflects both grammatical and lexical errors. Since AD patients made more lexical but not grammatical errors in L1, relative to their controls, the finding of fewer correct utterances is likely due to a greater rate of lexical errors.

In L2, the performance of the AD group did not differ from that of its control group on any of the grammatical measures. Our data therefore evidence relative preservation of grammar in AD, consistent with much of the literature (Croisile et al., 1996; Kempler, Curtiss, & Jackson, 1987; Schwartz, Marin, & Saffran, 1979), and suggest that this preservation occurs in L1 and L2.

Six studies have examined speech in bilingual AD. While some report comparable difficulties in L1 and L2 (Dronkers et al. 1986; conference proceeding cited in Hyltemstam & Stroud, 1993), others report evidence suggestive of greater L2 difficulties (De Santi et al., 1989), or potentially of greater L1 difficulty (De Vreese et al., 1988). Code-switching observations (reviewed in Hyltenstam, 1995) suggest that L2 proficiency may affect the pattern of attrition across languages. In short, we do not have a clear picture of how AD affects linguistic components in L1 and L2. Data from our study suggest that AD spares L1 and L2 grammar, at least in the relatively early stages of the disease, but affects lexical processing, more so in L1 than in L2.

On the discourse level measures, the picture descriptions of AD patients were less informative than were those of healthy older adults, as reflected in fewer information units having been generated (e.g., the boy taking the cookie), in each language. One of the most robust findings in the picture description literature is this reduction in the information conveyed by the speech of AD patients (Almor et al., 1999; Bschor et al., 2001; Bucks et al., 2000; Croisile et al., 1996; Cummings et al., 1988; Ehrlich et al., 1997; Hier et al., 1985; Illes, 1989; Nicholas et al., 1985). As Obler (1999) pointed out, AD may affect the cognitive resources to generate an informative message, or it may affect the linguistic abilities to communicate such a message. The fact that AD speech was equally poorly informative across languages may point to a deficit at a conceptual level. Finally, AD patients produced a greater number of utterances in L1 than in L2. Together, these results suggest that bilingual AD patients, despite experiencing greater lexical difficulties in L1, communicate a comparable amount of information across languages and may be more verbose in L1. Thus, AD affects the efficiency with which patients communicate.

Overall, the findings in L1 replicate those that demonstrate greater lexical than grammatical impairments in AD, with patients having displayed lexical difficulties on several measures, but having displayed evidence of grammatical limitations on the one measure, the percent of correct utterances, that is sensitive to both grammatical and lexical errors. The data suggests that AD may have a greater impact on L1 than on L2, as no impairments were observed on any of the lexical or grammatical measures within L2. It may be that fewer inhibitory resources are needed to retrieve items from a smaller L2 lexicon, leading to better L2 than L1 performance. As expected, poverty of content was observed in AD speech, equally so in L1 and L2.

<u>Memory and Language in PD</u>

The declarative memory performance of the PD group was almost indistinguishable from that of the healthy participants. As predicted, PD patients performed as well as their controls on the non-verbal and verbal tests of declarative memory, the BEM and RAVLT respectively. However, contrary to expectations, the PD group did not provide strong evidence of impaired procedural memory. In the non-verbal domain, we failed to replicate Westwater et al. (1998). The healthy participants displayed implicit sequence learning on the SRT but so did the PD group. This learning was expressed as follows: The naming latency of the two groups was significantly higher on Block 5, in which the asterisk appeared randomly at one of four locations at the bottom of the computer monitor, than on Block 4, in which the asterisk appeared in the same sequence for the 40^{th} to 50^{th} time. This difference in naming latency between Blocks 5 and 4 could be an accurate reflection of sequence learning in PD or it could be the result of fatigue. The SRT took approximately 20 min to complete. For this duration, the participant looked at the computer monitor and attended to the asterisk. This test was always the last memory test to be administered, and several participants inquired about the duration of the SRT. Fatigue may have partly contributed to the increase in naming latency observed on the last block, Block 5, which was also the randomized block. If so, it is possible that PD patients experienced greater fatigue than healthy subjects. As a consequence, fatigue could have inflated the learning score of the PD group relative to that of the NCPD group (naming latency in Block 5 minus Block 4). In sum, it is possible that a mild deficit in sequence learning in PD patients went undetected on the SRT because of the confounding effect of fatigue. On the mirror-reading task, the PD group displayed a repetition priming effect that was equivalent to that shown by the NCPD group. However, skill acquisition appeared dampened, and whereas the NCPD group displayed statistically significant skill acquisition, the PD group only displayed a statistical trend toward the same effect. Overall, the declarative memory findings suggest healthy medial temporal lobe function, but the procedural memory results provide limited evidence of impairments in the basal ganglia and/or basal-ganglia related circuitry.

Patients in this study were mostly in the early stages of the disease: On the Hoehn and Yahr scale, five or six patients were in Stages 1 or 2, two patients were in Stage 3, and none were in Stages 4 and 5. It is possible that the disease had not progressed enough for the impairments in procedural memory to be easily apparent. Based on the position that declarative memory is associated with the lexicon and L2 grammar, and procedural memory is associated with L1 grammar, PD patients were expected to be impaired on grammatical measures in L1 only, given that selective procedural memory deficits have been associated with PD (Gabrieli, 1998). However, given the absence of strong evidence of procedural memory difficulties in our patients, the interpretation of the data with respect to the link between procedural memory and language performance must be limited.

As expected, the performance of the PD group did not differ from that of the NCPD group on any of the lexical measures in L1. Patients and their controls produced a comparable percentage of unique nouns, unique words, pronouns, open-class words, and lexical errors. These findings provide evidence of intact lexical abilities in a native language in PD. However, differences were observed in L2, with PD patients having produced more lexical errors than their healthy controls. This finding may reflect working memory impairments, which have been documented in the literature on PD (e.g., Bublak et al., 2002). If the processes sustaining lexical retrieval are more automatic in L1 than in L2 (see Segalowitz & Hulstijn, 2005, for a discussion of automaticity), and if controlled processes place more demands on working memory than automatic ones, then working memory limitations could interfere with lexical retrieval in L2 to a greater extent than in L1. Cross-linguistic comparisons revealed that PD patients tended to have talked more in L1 than in L2. This may be due to subtle limitations in articulation. For late bilinguals, L1 words can be easier to pronounce than L2 words. Given subtle articulation difficulties, PD patients may tend to be more verbose in L1. Finally, the PD group tended to have produced fewer unique words in L1 than in L2, but they did not differ from their controls on that measure in L1 or in L2. Overall, the results in L1 are consistent with those reported in the literature, with PD patients not displaying lexical difficulty (Lewis, Lapointe, Murdoch, & Chenery, 1998). Results in L2 are equivocal, with PD patients having made more lexical errors than their controls, perhaps due to working memory limitations.

As expected, the performance of the PD group differed significantly from that of its control group on sentence level measures. PD patients made more grammatical errors relative to the number of utterances spoken and produced fewer correct utterances than their healthy counterparts, in each language. The finding of grammatical difficulties in the PD group in L1 replicates findings in the literature (Cummings et al., 1988; Grossman, 1999; Illes, 1989; Illes, Metter, Hanson, & Iritani, 1988; Murray 2000). However, the grammatical impairments of PD patients were equally prominent in L2 as in L1. This stands in contrast to Zanini et al. (2004) who found greater impairments in L1 than L2 in twelve Friulian-Italian bilingual PD patients. However, Zanini et al. (2004) assessed syntactic comprehension and not production. Syntactic correctness judgments can be performed using metalinguistic knowledge (i.e., information learned in school about grammatical rules), which may be more extensive in the language of schooling, in this case Italian. In this study, the narrative of the PD patients and of their controls did not differ on the average number of words per utterance, which was comparable across language, and on the percent of subordinate clauses, which was greater in L1 than in L2. As expected, the picture descriptions of PD patients contained just as many information units as those of healthy older adults, and contained a comparable number of utterances.

In sum, the results in L1 tend to support the declarative and procedural model of the lexicon and grammar. PD patients differed from their controls on two grammatical measures, but not on any lexical measure. In L2, PD patients displayed grammatical and lexical impairments, which does not support the position that L2 grammar and the lexicon are dependent upon declarative memory.

<u>Summary</u>

This study reflects interest in helping to elucidate the interaction of memory and language. It specifically aimed to determine whether a disease that primarily affects declarative memory would affect the lexicon and L2 grammar, and whether a disease that primarily affects procedural memory would predominantly affect L1 grammar. The results are equivocal. AD and PD patients both showed some deficits, relative to healthy older adults, on lexical and grammatical measures. In L1, the performance of the patients generally replicated findings from the literature, which are consistent with the position that grammar and the lexicon depend more on procedural and declarative memory, respectively. AD patients used more pronouns and fewer open-class words than their healthy counterparts, and made more lexical errors. At the sentence level, the AD group differed from its control group only by having produced fewer correct utterances. although this observation may reflect the greater percentage of lexical errors. Finally, the speech of AD patients contained fewer information units than that of healthy older adults.

In short, the AD group clearly displayed greater lexical than grammatical impairments in L1. PD patients, on the other hand, differed from their healthy counterparts primarily on grammatical measures, having produced more grammatical errors and fewer correct utterances. These results in both patient groups are as expected based on the position that in L1, the lexicon is more closely associated with declarative memory and grammar is more closely associated with procedural memory.

What the data do not support is the position that whereas L1 grammar is dependent upon procedural memory, L2 grammar is more reliant upon declarative memory. Said differently, it is the pattern of results across languages that is not as expected based on the declarative and procedural model of the lexicon and grammar. The AD patients, who displayed declarative memory deficits and significant lexical impairments in L1, did not display significant L2 grammatical difficulties. For the PD group, patients generated fewer correct utterances and made more grammatical errors than their control group in L2, and there was a statistical trend for this effect to have occurred in L1 as well. PD patitents displayed some lexical impoverishment in L1.

Implications

The results indicate that age and age-related diseases may affect different languages differently. In practice, this means that an examiner in a clinical setting cannot assume that a patient's best language performance is obtained in L1. Whether L1 or L2 is better preserved is likely to depend on the memory challenge imposed by the specific disease process. Data from this study would suggest that AD may be associated with greater decline in L1, and that PD may lead to language difficulties across languages. The results highlight the importance of distinguishing language preference from language ability. In the code-switching literature, the tendency of bilingual AD patients to revert to their L1 is sometimes interpreted as indicating that L1 is better preserved. Our data suggests that this may not be the case. Code-switching was not observed in this study.

Limitations

An important challenge to testing Paradis and Ullman's neurolinguistic models of bilingualism is that to meaningfully compare decline in L1 and L2, patients need to have been fluent in each language pre-morbidly. Otherwise a weaker L2 performance, for instance, could not be attributed to the disease. Fluency is developed through practice. An L2 learner may learn metalinguistic knowledge about L2 in class, but will unlikely become fluent unless this knowledge is put into practice in conversation. To the extent that the conversation is meaningful, the L2 learner is developing implicit linguistic competence. When a potential study participant reports feeling equally or almost equally comfortable in L1 and L2, to meet inclusion criteria, it is usually that he/she has had considerable real-life experience using L2, regardless or the method with which L2 was initially learned. In research with older populations, this factor is compounded by age, as older participants may have had 40-60 years of experience using L2. Paradis and Ullman's hypotheses are realistic in positing that it is the "extent" to which grammar relies on procedural and on declarative memory that differs between L1 and L2. The challenge is whether the extent of that difference is large enough to be detected within a sample of older adults reporting approximately equal proficiency, and whether the difference is meaningful. It may be that the only difference between L1 and L2 in a proficient bilingual is that in L1, one acquires implicit linguistic competence before metalinguistic knowledge, whereas in L2, one learns metalinguistic knowledge before developing implicit linguistic competence. In other words, the declarative and procedural memory systems may be equally involved in the processing of L1 and L2, once a certain level of proficiency is attained. If this is the case, testing Paradis and Ullman's neurolinguistic models would require a longitudinal design and not a cross-sectional one, such as the one used here. A cross-sectional design cannot accommodate for different pre-morbid levels of L1 and L2 fluency, but a longitudinal design can. For instance, groups of bilingual AD and PD patients could be selected that have had extensive formal education in L2 but limited practice in conversation. The patients would likely report feeling more comfortable in L1 and being less proficient in L2. These patients would possess great metalinguistic knowledge but restricted implicit linguistic competence in L2. The patients may score lower on L2 measures than on L1 measures, initially, but their performance could be tracked over time to determine whether AD leads to more decrements in L2 and whether PD leads to more deterioration in L1.

Some limitations are intrinsic to research on bilingualism. Language proficiency is an umbrella term under which enormous individual differences may lie. Individual differences can be found across linguistic domains (e.g., phonology, morphology, syntax, lexicon, semantics, etc), across domains of knowledge (e.g., an individual having completed his/her university education in L2 may not be as fluent in L1 in academia-related communication), and across modality (e.g., reading versus writing), to cite only a few. Bilinguals differ on how they acquired or learned their L2 (e.g., age, manner, motivation) and how they maintain it (e.g., frequency of use, purpose, modality). With regard to acquisition, de Bot and Makoni (2005) point out, "it is not easy or even possible to define exactly which part of an individual's language has been acquired implicitly or explicitly". With regard to maintenance, there is the issue of attrition, as skills develop with use and decline with non-use (de Bot & Makoni, 2005). Language is a dynamic phenomenon that evolves in time. In addition, just as there is tremendous variability within a sample of bilinguals, patient populations, such as AD and PD, are notoriously heterogeneous. Finally, bilingual AD and PD patients meeting specific linguistic criteria are extremely difficult to recruit. This limits sample size, which in turn limits the power to detect significant effects. In conclusion, research on bilingual AD and PD is intrinsically challenging, and much research will be needed before a clear understanding of the effect of age or age-related diseases on language in bilinguals emerges.

Future Directions

As previously described, a longitudinal study would be ideally suited to test the hypotheses of the current study. Aside from measures of declarative and procedural memory, and of different aspects of language, measures of working memory, inhibition, and processing speed could be informative. It could be, for instance, that memory and language are linked, but mostly through working memory, or specifically through the inhibitory processes of working memory. This could explain some of the overlap in the performance of the bilingual AD and PD samples. A reduction in processing speed has been documented in aging (Salthouse, 2000), and is likely to occur in AD and PD. Yet, no research on the interaction between aging and processing speed in L1 and L2 has been conducted, as de Bot and Makoni (2005) point out. It is unclear whether a decrease in speed of processing would affect skilled performance more so than controlled performance. If this were so, a significant reduction in processing speed in AD could affect implicit linguistic competence more than the controlled speeded-up, application of metalinguistic knowledge, leading to the observation of greater L1 than L2 impairments.

Future research on bilingual dementia could compare the performance of monolingual and bilingual AD patients, matched for instance on non-verbal measures of memory and stage of dementia. As stated by de Bot & Makoni (2005) "There is substantial evidence that the first language, which for a long time was considered to be more or less immune to changes after puberty, is influenced by the use of other languages". It would be interesting to see whether knowing another language, which has been associated with greater cognitive flexibility and inhibitory capacity in children (see Bialystok, 2005), and better preservation of executive functions in older adults (Bialystok, Craik, Klein, & Viswanathan, 2004), could buffer the effect of AD on L1. Alternatively, bilingual AD patients could be at a disadvantage, since there are more languages that use the cognitive resources for language processing.

In conclusion, much of how aging and age-related diseases affect L1 and L2 remains to be uncovered. This study was the first to examine picture description in samples of bilingual AD and PD patients, and the findings suggest that AD affects primarily lexical processing, more so in L1, and PD affect mostly grammatical processing but equally so in L1 and L2. Further research, ideally employing a longitudinal design, on samples that are comparable but also on populations that differ from the ones in this study, in terms of participant characteristics, such as proficiency, is likely to shed more light on how memory, and other cognitive abilities, affect language in bilingual or multilingual healthy older adults and AD and PD patients.

Manuscript 2

Memory and Language in Bilingual Alzheimer and Parkinson Patients: Insights from Verb Inflection

Abstract

This is the first study to directly contrast the effect of aging or age-related disorders on grammar and the lexicon in a native (L1) versus a second (L2) language. We tested 16 young and 16 older adults, and 8 Alzheimer (AD) and 9 Parkinson (PD) patients, all French/English bilinguals who had learned L2 after age 8. Participants generated the past tense of irregular and regular verbs embedded in sentences. Response accuracy and latency were measured. Neurolinguistic theories suggest that lexical ability, required to generate the past tense of irregular verbs and L2 regular verbs, is closely linked to declarative memory, whereas grammatical ability, required to generate the past tense of L1 regular verbs, is linked to procedural memory (Paradis, 1994; Pinker, 1999; Ullman, 20001). Since aging relatively spares procedural memory and the semantic aspects of declarative memory (Flicker et al., 1986), the past tense generation performance of young and older adults was expected to not differ. Since AD affects declarative memory, and PD procedural memory, AD patients were expected to be impaired in generating the past tense of irregular and L2 regular verbs, whereas PD patients were expected to be impaired in generating the past tense of L1 regular verbs. The performance of older adults was comparable to that of younger adults. While the results for the effect of verb type were mitigated by the fact that all participants made more errors inflecting L2 irregular verbs, the findings provide some support for AD affecting L2 to a greater extent than L1, and PD impacting L1 to a greater extent than L2.

Memory and Language in Bilingual Alzheimer and Parkinson Patients: Insights from Verb Inflection

Recent estimates reveal that over half of the world population is bilingual or multilingual (Grosjean, 1982; cited in Fabbro, 1999). This suggests that many patients suffering from Alzheimer's disease (AD) and from Parkinson's disease (PD) speak more than one language. Yet few studies have investigated language in bilingual AD (De Vreese et al., 1988; Dronkers et al., 1986; Friedland & Miller, 1999; Hyltenstam & Stroud, 1989, 1993; De Picciotto & Friedland, 2001; De Santi et al., 1989; Meguro et al., 2003). Only one has examined language in bilingual PD (Zaninini et al., 1996). The scarcity of research in the area is surprising given its applications for the care of AD and PD patients, and given its implications for theories of language and memory. Specifically, AD and PD each affect a neurofunctionally distinct memory system. As such, the inspection of language in bilingual AD and PD offers a truly unique insight into the nature of the relationship between memory and language, and into the neural underpinnings of language functions. The goal of this study is to test the usefulness of a neurolinguistic model in explaining language disturbances in bilingual AD and PD, which posits links between neurofunctionally separable memory systems and specific language functions.

Declarative and Procedural Memory

Memory is not unitary, and dissociations in the task performance of healthy and patient populations have prompted the proposal of taxonomies, such as the declarative and procedural memory taxonomy (Cohen & Squire, 1980; Cohen, 1984). Declarative memory literally refers to the ability to recount what one knows. It can integrate new information from various modalities, and is flexible in that respect. For instance, a person can expand his/her animal-related knowledge by reading on the topic and by visiting a zoo. Converging evidence from lesion and neuroimaging studies, reviewed in Gabrieli (1998) suggests that regions of mesial temporal lobe that include the hippocampus, entorhinal cortex, and parahippocampal cortex sustain declarative memory. These areas interact with cortical brain regions for the conscious retrieval of facts and events (see Gabrieli, 1998). By contrast, procedural memory refers to memory for ways of doing things or for movements. This memory is independent from that used to explain these same ways of doing things or movements. Procedural memory is inflexible such that new information cannot easily be incorporated with knowledge already acquired. For instance, a typist may not be able to tell easily the location of keys on the keyboard, and the ability to type does not allow the typist to play the piano. Empirical findings, reviewed in Gabrieli (1998) suggest that subcortical structures, the basal ganglia in particular, are involved in skill learning and maintenance. These regions project to areas of the frontal cortex through specific striatal-thalamic-cortical loops that sustain particular motor, perceptual, and cognitive skills (see Gabrieli, 1998).

Metalinguistic Knowledge and Implicit Linguistic Competence

Although the nature of the relationship between memory and language remains unclear, similarities can be noted between declarative memory and lexical functions, and between procedural memory and grammatical functions. Paradis (1994, 1997, 1998a, 1998b, 2004) has linked "metalinguistic knowledge" to declarative memory, and "implicit linguistic competence" to procedural memory (these terms are defined below). In a similar vein, Ullman (2001) highlights the association between the "memorized mental lexicon" and declarative memory, and between "computational mental grammar" and procedural memory.

According to Paradis, "metalinguistic knowledge" is dependent upon declarative memory. It is learned in a conscious manner, it is available for conscious recall, and is applied to language in a controlled fashion. As stated in Paradis (1994), metalinguistic knowledge is dependent on the integrity of the hippocampal system, and stored diffusely over large areas of tertiary cortex. Ullman (2001) refers to the components of language to which these characteristics apply as the "memorized mental lexicon" and hypothesizes a correspondence in learning, representation, and processing, among lexical items, facts, and events. The individual who can perfectly recite a rule of grammar for a second language (L2), but is incapable of applying that rule when speaking possesses good metalinguistic knowledge but poor implicit linguistic competence.

By contrast, according to Paradis (1994), "implicit linguistic competence" relies on procedural memory. It is acquired incidentally, stored as procedural know-how, used without effort, and mediated by subcortical structures, mainly the basal ganglia and cerebellum. Ullman (2001) refers to facets of language to which these characteristics apply as the "computational mental grammar". According to Ullman, the grammar contains rules, including operations and constraints, which underlie the productive combination of lexical forms into complex structures such as sentences or words (e.g., the past tense of regular verbs can be computed by adding "ed" to the verb stem, like "walk" + "ed" = "walked). Ullman (2001) posits a correspondence in learning, representation, and processing, to grammar, skills, and habits, respectively. Implicit linguistic competence in the absence of metalinguistic knowledge is displayed by the young child who can tell if a sentence in his/her native language (L1) is acceptable or not but yet cannot articulate a reason other than "that it does or does not sound right". An adult in the early stages of learning would have more difficulty using this method to decide if an L2 sentence is grammatically correct or not.

Evidence for the dissociation between "metalinguistic knowledge or memorized mental lexicon" and "implicit linguistic competence or computational mental grammar" comes from research on aphasia (Damasio, 1992; Goodglass, 1993). Aphasics with damage to temporoparietal areas including Wernicke's area have been shown to display word-finding deficits in the absence of obvious defects in the syntactic structure of speech (i.e., their speech lacks content but does not bluntly disobey grammatical rules). By contrast, aphasics with damage to Broca's area that descends to the basal ganglia display agrammatism and poor syntactic comprehension, with relatively intact access to word meaning. Evidence for the association between "metalinguistic knowledge or memorized mental lexicon" and declarative memory, and between "implicit linguistic competence or computational mental grammar" and procedural memory, comes from research on neurodegenerative diseases such as AD and PD, and it is reviewed in the following paragraph:

Declarative Memory and Metalinguistic Knowledge

AD initially affects the hippocampus, entorhinal cortex, and the association cortices (Hyman et al., 1984). These regions sustain declarative memory and, in fact, declarative memory impairment is a hallmark of AD (see Gabrieli, 1998 for a review). AD spares, at least at the outset, subcortical areas of the frontal lobes including the basal ganglia and, as expected, aspects of procedural memory are relatively spared in AD (see

Gabrieli, 1998). If declarative memory sustains metalinguistic knowledge (the memorized mental lexicon) and not implicit linguistic competence (the computational mental grammar), AD patients should display lexical deficits in the context of relatively intact grammatical processing. Cummings et al. (1988) found the speech of AD patients to contain a high proportion of closed-class phrases, ill-defined pronouns, and words or utterances that convey little or no information. The patients' speech was in general grammatically correct despite not being clear at a semantic level. The observation of impaired lexical function in the context of relatively spared grammatical ability in AD has been replicated by many (for a review, see Caramelli, Mansur, & Nitrini, 1998), and even prompted Mathews, Obler, and Albert (1994) to draw a parallel between AD speech and that of Wernicke's aphasics.

Procedural Memory and Implicit Linguistic Competence

PD is characterized by the loss of dopamine in the basal ganglia and associated brain region such as the caudate nucleus (McDowell et al., 1978). These regions sustain procedural memory, and as expected, procedural memory has been shown to be impaired in PD, in studies reviewed in Gabrieli (1998). Idiopathic PD spares the hippocampus, entorhinal cortex, and temporo-parietal cortex, and as predicted spares declarative memory, as described in Gabrieli (1998). If procedural memory sustains implicit linguistic competence (or the computational mental grammar) and not metalinguistic knowledge (or the memorized mental lexicon), PD patients should display grammatical deficits in the context of relatively intact lexical processing. Cummings et al. (1988) found the free speech of PD patients to be marked by diminished grammatical complexity, as shown in decreased phrase length, the production of fewer dependent clauses, and greater use of open-class phrases. Dysarthria, abnormally long hesitations, and impaired prosody are also a hallmark of PD speech. Grossman (1999) provides a review of comparable findings. By contrast, the naming ability of non-demented PD patients has been shown to be normal (e.g., Lewis et al., 1998).

Evidence from Verb Inflection

Lexical and grammatical abilities can be tested in several ways. One paradigm for examining the two abilities is the Past Tense Generation task (PTG). The PTG requires the subject to generate the past tense of irregular and regular verbs that are embedded in meaningful sentences, and permits the concurrent evaluation of lexical and grammatical abilities. Based on the dual-system model of verb inflection (see Pinker, 1999), the past tense of regular verbs in L1 is generated productively by adding "ed" to the verb stem (e.g., "walk" + "ed" = "walked"). By contrast, the past tense of irregular verbs (e.g., "taught") must be retrieved from declarative memory since it cannot be derived from the stem (e.g., "teach"). In sum then, the dual-system model posits that generating the past tense of irregular verbs is a lexical function, whereas generating the past tense of regular verbs in L1 is a grammatical function. The performance of healthy and patient populations on the PTG has provided evidence for the dual-system model of verb inflection. For instance, it has been empirically demonstrated that the past tense of frequent irregulars is generated faster than that of less frequent irregulars, as expected if these are retrieved from declarative memory, whereas frequency has no effect on the latency to generate the past tense of regular verbs, as expected if these are generated productively (see Pinker, 1999; Ullman, 1999).

The PTG has been implemented in many languages including French (e.g., Rose & Royle, 1999), English (e.g., Ullman et al., 1997), German (e.g., Marcus et al., 1995), and Italian (e.g., Orsolini et al., 1998). It has been used to study a variety of language disorders such as specific language impairment (e.g., Ullman & Gopnik, 1999). The PTG is well controlled in that the stimuli used to test lexical and grammatical abilities can be matched on complexity (i.e., one word), syntax (i.e., tensed), and meaning (i.e., past). The demand on short-term memory can be matched by making the sentences that embed the verbs the same length and complexity. These features of the PTG make it ideal to compare the performance of patient populations that differ in their cognitive impairment, such as AD and PD. Ullman et al. (1997) had AD and PD participants generate the past tense of regular verbs, irregular verbs, and pseudo-verbs. As predicted based on the dual-system model of verb tense inflection and on the selective memory deficits of the two patient groups, AD patients demonstrated preponderant impairments in declarative memory and made more errors producing the past tense of irregular than regular verbs and pseudo-verbs, whereas PD patients made more errors producing the past tense of regular verbs and pseudo-verbs than irregular verbs.

Verb Inflection in Bilinguals

Ullman (2001) reviewed evidence from bilingual aphasia, neuroimaging, and psychophysiology, which indicate that the lexicon/grammar dissociation observed in L1 is weaker in L2. More specifically, whereas grammar in L1 is dependent upon procedural memory, L2 grammar, when learned after puberty in an academic context, is dependent to a greater extent upon declarative memory. An example of the evidence supporting this distinction is the observation of a critical period for the acquisition of grammar but not for the lexicon (Birdsong, 1999; Johnson & Newport, 1989), as well as differences between L1 and L2 speakers in processing closed-class words (e.g., prepositions), which have grammatical functions, but not in processing open-class words (e.g., nouns), which have lexical functions (Weber-Fox & Neville, 2001).

With the exception of Brovetto and Ullman (2001), the PTG has not yet been used to test the lexicon and grammar in bilinguals to our knowledge. Brovetto and Ullman compared the performance of English-L1 speakers to that of English-L2 speakers on the PTG. The native English speakers displayed frequency effects for irregular verbs but not for regular verbs, in English, as predicted if the past tense of irregular verbs is retrieved from declarative memory whereas that of regular verbs is generated productively by adding "ed" to the stem. L2 speakers of English showed frequency effects for both irregular and regular English verbs, indicating that they were retrieving the past tense of both types of verbs from declarative memory. This finding is consistent with the argument that grammar in L1 is dependent upon procedural memory but L2 grammar, when learned after puberty in an academic context, is dependent to a great extent upon declarative memory, and is also in accordance with the aphasia, neuroimaging, and psychophysiological evidence reviewed in Ullman (2001). The lexicon and grammar has not yet been examined in bilingual AD and PD patients in a single study.

<u>This Study</u>

The goal of this study was to examine verb inflection in bilingual young (YC) and older healthy adults (NC), and in bilingual AD and PD patients. Each patient group was assigned its own control group, matched on characteristics such as age and education (NCAD and NCPD, for the AD and PD group respectively). Subjects were French-

English or English-French bilinguals, who had acquired their L2 after puberty. The PTG was adapted to allow us to measure response latency. A battery of memory tests was selected to document selective declarative memory deficits in the AD patients and selective procedural memory deficits in the PD group.

From the literature review, and based on the dual-system model of verb inflection, the following predictions were made for healthy bilinguals: In L1, they were expected to show frequency effects for irregular verbs but not for regular verbs, if the former are retrieved from memory and the latter are generated productively. In L2, they were expected to show frequency effects for both irregular and regular verbs if the past tense of both verb types is retrieved from memory. Since bilinguals may not be as fluent in L2 as in L1, greater accuracy for L1 verbs could be anticipated, especially for irregular verbs, which may be more vulnerable to exposure (or lack thereof) to the past tense form. As aging affects mostly the episodic aspects of declarative memory (i.e., memory for temporally dated episodes) rather than its semantic aspects (i.e., memory for facts, concepts, and vocabulary; Flicker et al.,1986), and spares procedural memory (Smith & Fullerton, 1981), young and older adults were expected to perform similarly on the PTG. For the patient populations, the following hypotheses were generated:

Bilingual AD: Given the neuropathology of AD, these patients were expected to be impaired on tests of declarative memory but not on tests of procedural memory. This finding would be consistent with the literature on memory in AD, which is reviewed in Gabrieli (1998). In L1, AD patients were expected to make more errors in generating the past tense of irregular verbs than regular verbs and pseudo-verbs. This would replicate Ullman et al. (1997). In L2, AD patients were expected to make more errors than normal controls for both regular and irregular verbs, since in L2 both rely on declarative memory to a great extent. The predictions for L2 have not been tested in AD, to our knowledge. One of the eight studies published on bilingual AD examined semantic fluency and reported that AD patients showed a trend toward greater fluency in L1 than in L2 (De Picciotto & Friedland, 2001). Another study measured naming ability and demonstrated that AD patient were impaired in L1 and L2 but more so on items that could not be derived from rules such as words without grapheme and sound correspondence (Meguro et al., 2003). All other studies on bilingual AD were concerned with code-switching and did not contrast grammatical and lexical ability. Nevertheless, the observation that AD patients switch into L1 to a greater extent than into L2 (Dronkers et al., 1986; Hyltenstam & Stroud, 1989, 1993; Santi et al., 1989) and prefer L1 to L2 (e.g., Mendez, Perryman, Ponton, & Cummings, 1999) is consistent with the view that AD affects an L2 more than an L1 (Obler, 1999; Paradis, 1999). Frequency effects were not expected for AD participants because these are the product of successful retrieval from declarative memory, and declarative memory deficits are a hallmark of AD.

Bilingual PD: Given the neuropathology of PD, these patients were expected to be impaired on tests of procedural memory but not on tests of declarative memory. This finding would be consistent with the literature on memory in PD, described in Gabrieli (1998). In L1, PD patients were expected to make more errors in generating the past tense of regular verbs and pseudo-verbs than irregular verbs. This would replicate Ullman et al. (1997). In L2, PD patients were expected to perform similarly to normal controls, since the generation of the past tense of irregular and regular verbs in L2 minimally involves procedural memory. The prediction in L2 has not been tested yet in

PD, although Zanini et al., (2004) showed greater syntactic impairments in L1 relative to L2 in bilingual PD patients using tests of sentence comprehension and syntactic judgment. Similarly to healthy participants, PD patients were expected to display frequency effects for irregular verbs in L1 and L2 and for regular verbs in L2. If the patients compensate for their inability to productively generate the past tense of regular verbs in L1 by retrieving the past tense forms from declarative memory (e.g., "walked"), then we would expect to observe frequency effects for regular verbs in L1 as well.

In sum, a double dissociation was expected in the memory performance of the patient groups, with AD patients being selectively impaired on tests of declarative memory and PD patients being selectively impaired on tests of procedural memory. A double dissociation was similarly expected in the PTG performance of the patients, with AD patients being more impaired in generating the past tense of irregular verbs in L1 and L2 and regular verbs in L2, and PD patients being more impaired in generating the past tense of regular verbs in L1.

Method

Participants

Sixteen healthy young (young controls: YC) and 16 healthy older controls (normal controls: NC), nine PD patients, and eight AD patients, were tested. Healthy participants were recruited through advertisements, whereas neurologists referred the patients. Participants were screened for major past or current health or mental problems. Those with conditions known to affect cognition (other than AD and PD) were excluded. Ethical approval was obtained and all participants gave informed consent. All participants were fluent in English and in French. Bilingualism was assessed with the History of Bilingualism questionnaire, and the English Background and French Background questionnaires from the Bilingual Aphasia Test (Paradis, 1987). The inclusion criteria included: 1) feeling equally or almost equally comfortable in English and French, 2) using L2 at least 30% of the time on a daily or weekly basis, and 3) having learned L2 enough to speak it fluently after about age 12. All participants learned their L2 in school, with the exception of one young control, two healthy older controls, three PD patients and two AD patients who learned their L2 mostly through real-life interactions. All participants learned their L2 after age 12, except for three YC and one NC participants, and three AD participants who learned their L2 at about 8 years of age. Since the AD group was older than the PD group, each group was assigned its own control group (NCAD and NCPD, respectively). For each patient, a participant from the NC group was selected that best matched that patient's demographic characteristics. Four of the participants from the NC group each served a healthy control for both an AD and a PD patient. This method may have lead to a small increase in the probability of

Type I error, but was needed to ensure that each patient had a matched control participant as similar to him/her as possible with regards to important demographic and linsuistic characteristics. Characteristics for each patient group and its control group are reported in Table 1, and for each pair of patient and his/her matched control, in Appendix C. The PD group did not differ statistically from its control group on any of the variables presented in Table 1, i.e., mean age, years of education, age when became fluent in L2, and percent of current L2 use in daily life (t_s [16] = .12, .63, -.45, 1.85, respectively, $p_s >$ .05). The AD group had significantly fewer years of education than its control group (t [14] = -3.36, $p < .05$), and became fluent in L2 at a slightly younger age than its control group did (t [14] = -2.43, $p < .05$), but both groups were of a comparable age (t [14] = 1.89, $p > .05$) and used L2 as frequently (t [14] = .04, $p > .05$). The younger and older groups did not significantly differ on years of education (t [30] = .49, $p_s > .05$) or current L2 use in daily life (t_s [30] = 1.35, $p_s > .05$), but differed on age of L2 fluency (t_s [30] = , $p < .05$) and age (t_s [30] = -23.69, $p_s < .05$).

AD patients were mildly to moderately demented based on the Mini Mental State Exam (range 16-27; mean 23). Information on health and language volunteered by the AD patients was verified with their spouses, when possible. PD patients were not demented based on evaluations by the referring neurologist. The decision to select non-demented PD patients was motivated by the fact that dementia in PD could indicate concomitant AD, or another disorder altogether. On the Hoehn and Yahr scale (Hoehn & Yahr, 1967), seven PD patients were within Stages 1 and 2, whereas two were within Stages 3. None of the patients were within Stages 4 or 5. All PD patients were

Table 1. *Characteristics of the participant groups.*

	YC	NC	NCAD	AD	NCPD	PD
Sample size	16	16	8	8	9	9
Age range	19-32	52-74	65-74	58-83	52-74	55-79
Mean age	25	65	70	76	66	65
	(3.52)	(5.86)	(3.11)	(9.01)	(7.75)	(8.93)
Education (in years)	16 (2.39)	16 (2.64)	16 (2.03)	12 (2.55)	16 (2.73)	15 (4.61)
Having French as L1	13	13	7	7	8	6
Mean age felt fluent in L2	13 (4.51)	20 (4.19)	16 (3.76)	13 (4.81)	20 (4.58)	20 (4.66)
Range age felt fluent in L2	6-19	8-45	8-20	6-18	14-20	15-30
Mean percent of the time spent in L2 currently	55	47	50	50	48	38
	(21.39)	(16.07)	(18.32)	(18.08)	(11.97)	(10.13)

<u>*Note:*</u> *SEs are presented in parentheses.*

YC = Young controls. NC = Older normal controls.

NCAD = Normal controls for the AD group.

NCPD = Normal controls for the PD group.

medicated and each was tested at a time of day when he/she reported the symptoms were least. The memory tests described below are as described in Manuscript 1.

Declarative and Procedural Memory Tests

Memory was assessed in each participant's L1 in the non-verbal and verbal domains. Only tests that do not require a manual response were selected. Declarative memory was assessed in the non-verbal modality with the Batterie d'Efficience Mnésique (BEM-144; Signoret, 1991) and in the verbal modality with the Rey Auditory Verbal Learning Test (RAVLT; Lezak, 1983). The BEM required subjects to recognize simple designs, whereas the RAVLT required them to learn and remember a list of simple nouns. The RAVLT has been shown to be sensitive to AD (see Spreen & Strauss, 1991). The BEM has not been used in research on AD to our knowledge, but it was chosen because it does not require subjects to draw, as opposed to more commonly used tasks that require copying a figure and/or drawing it from memory after a delay.

Procedural memory was evaluated in the non-verbal modality with the Serial Reaction Time task (SRT; Westwater et al.,1998) and in the verbal domain with the mirror-reading task (Deweer et al., 1994). The SRT is a measure of sequence learning. The participant tracks a star that appears on a computer monitor following a spatial sequence. Participants are usually unaware of the sequence but yet their tracking speed increases with increasing exposure to the sequence. The mirror-reading task measures the acquisition of the ability to read words printed backwards. These tasks were chosen because they have been shown to be sensitive to PD (Westwater et al., 1998 for the SRT; Koenig et al., 1999 for the mirror-reading task) but not to AD (Knopman & Nissen, 1987 for the SRT; Deweer et al., 1993 for the mirror-reading task).

BEM: This test required subjects to recognize 24 simple and abstract designs. Each black and white design measured 6 cm^2 and was printed on a separate 8.27 X 11.69 in. page. Each design was presented for 5 s and the participant was asked to observe it carefully because it would have to be recognized among 3 foils later. After a 30-minute delay, each of the 24 designs was presented among 3 foils. Each black and white design measured 6 cm^2 and each foil appeared only once. The participant was told that he/she had seen one of the four designs, presented in one column on the page, and asked to point to the one he/she recognized. The number of designs correctly recognized was measured.

RAVLT: This test required subjects to learn and remember a list of words. The participant heard a list of 15 familiar nouns (List A), read at a rate of one word per second, and was asked to recall as many as possible in any order. This procedure was repeated five times. For each recall, the minimum time allowed was 45 s and the maximum was 2 min. After the five trials, the participant heard another list of 15 words (List B) and was asked to recall as many words as possible from this list only. Following this interference trial (i.e., List B), the participant was asked to recall the words from List A. Following a 30-minute delay, recall was tested unexpectedly for List A and recognition evaluated for Lists A and B. For the recognition test, List A and B words were presented among 20 foils. Some of the foils were semantic associates of the target words whereas others were phonetic associates. The French version of the RAVLT was obtained from M. Jonesgotman. There were six measures of interest: 1) The number of words recalled on the first learning trial, 2) The number of words recalled on the final learning trial, 3) The total number of words recalled across the five learning trials, 4) The number of words recalled after interference, 5) The number of words recalled from List A after the delay, and 6) The number of words from List A and B correctly recognized.

SRT: This test of sequence learning was implemented as described in Westwater et al. (1998). On each trial, an asterisk appeared at one of four locations at the bottom of the computer monitor. The four locations (1, 2, 3, 4) were equidistant along the horizontal axis. The asterisk appeared on the monitor in the following 10-trial sequence: 4231324321. Upon a response, the asterisk disappeared and 400 ms later it reappeared at a different location for the next trial. There were five blocks of trials. The first four blocks comprised 10 repetitions of the 10-trial sequence. The fifth block consisted of 100 trials presented in random order with the constraint that the asterisk did not appear at the same location consecutively. The blocks were separated by a 1-min pause. Before initiating the task, the participant was shown the four locations and was then instructed to name the location out loud as soon as the asterisk appeared on the monitor. Naming latency was recorded through Inquisit (Millisecond Software). Upon completion of the task, the participant was asked whether he/she noticed anything and if he/she believed his/her naming latency decreased with practice. If the participant referred to a sequence, he/she was asked to tell the order.

Mirror-reading: This test of skill acquisition and repetition priming was implemented to resemble that described in Deweer et al. (1994). All words were six to seven letters long. Word frequency varied between 1 to 22 occurrences per million words in written language. Word frequency norms for the English version were taken from Francis and Kucera (1982), whereas those for the French version were collected from Beaudot (1992). There were three sets of stimuli, one for each learning session.

Each set consisted of 5 blocks of 10 word triads. Five word triads were unique to each block and five of the word triads were common to all blocks. The unique word triads were used to test skill acquisition, whereas the repeating triads were employed to assess repetition priming.

Within each block, the mean word frequency for the unique and for the repeat triads was 8.6. The mean frequency for the first, second, and third words of triads was matched within each block and across blocks, and varied between 8.5 and 8.6. The mean frequency for each set of five unique triads within each block varied between 7.1 and 10.2. The frequency of each of the five repeat word triads varied between 5.3 and 13.7, for an average repeat triad frequency of 8.6. The order of the words within the repeat triads varied across the five sets in a block, such that it was never the same. This description of the stimuli applies to both the English and the French version. The triads were printed in black ink upper case in a 53-point size Arial font using Microsoft Word 2000. Accents were included for the French version. The words within each triad were separated by a hyphen (e.g., SLEEVE-KENNEL-TWISTER). Using Adobe Photoshop 5.5, each triad was flipped over a vertical axis, and printed on a transparency for presentation to the participants. Each 8 ½ X 11 inch transparency was placed on top of an 8½ X 11 off-white sheet of paper.

Participants were told that the words had been flipped on a vertical axis and that therefore words had to be read from right to left. If the participant did not understand, the transparency was flipped to show a practice item in normal text. Two single-word practice trials were given, as well as one practice trial with a word triad. Participants were encouraged to read each triad as fast as possible. If a participant made an error, he/she was asked to correct the error. The time it took each subject to read each triad was measured with a stopwatch. A maximum of 2 min was allowed to read a triad. Each block of 50 triads was interspersed with other tasks. After completing the three blocks of 50 triads, recognition was tested for the triads that were common to all blocks. There were five triads that were present for each set of 10 triads within each block. This means that 15 words were repeated throughout the task. For the recognition test, these 15 words were embedded in 30 foils not semantically nor phonetically related to the repeat words. The average frequency of the foils was of 8.6, the same as that of the repeat words. Each of the 45 words was printed forward (i.e., not flipped) on an 8 ½ X 11 white sheet of paper in the same font as the other stimuli. The participant was shown each word and asked if he/she had read the word backward earlier in the test.

The Past Tense Generation Task

The PTG was comprised of three experimental conditions within each language: the regular verb, irregular verb, and pseudo-verb, conditions. For the English version, verbs were defined as regular if adding "ed" to the stem (e.g., "walk-walked") generates the past tense. They were defined as irregular if generating the past tense requires modifying the stem (e.g., "teach-taught"). Pseudo-verbs were English sounding pronounceable verbs that do not exist (e.g., "tunch"). The English verbs were selected from M. Ullman's database.

For the French version, it was necessary to choose between the imperfect tense (*imparfait*) and the perfect tense (*passé composé*) to mark the past. To mark the imperfect tense of a regular verb, the phoneme [ɛ] must be added to the stem for the 1st, 2nd, and 3rd person singular and the 3rd person plural, whereas to generate the perfect tense, an auxiliary verb must be inserted ("to be" or "to have") and the phoneme [é] added to the stem. The imperfect tense was selected for this study because it does not require an auxiliary verb and it is the only tense that can be defined for regular verbs as "stem" + "phoneme [ɛ]". Using the imperfect tense avoids this limitation of the perfect tense: If the auxiliary verb had been provided to the participants, we would not have known if the participant generated the correct verb tense (e.g., "aimé"), the infinitive (e.g., "aimer"), or the subjunctive 2nd person plural (e.g., "aimez"), since all three are homophones. Alternatively, if the auxiliary verb had not been provided to participants, the latency to generate the past tense form would have been confounded with the latency to generate the auxiliary verb. The imperfect tense does not share these limitations.

For this study, a French verb was defined as regular if it belonged to the first group of verbs, those that end in "er" in the infinitive and follow the same conjugation as "aimer". Over 10,000 verbs fall within this category (Bescherelle, 1981). The third person singular in the present tense was considered as the stem because it provides the sound part of the verb that does not change with inflection. Irregular verbs belong to the third group of French verbs, which include the verbs that do not belong to the first (those that end in "er" in the infinitive) or to the second group (those that end in "ir" in the infinitive). The third group of verbs forms a dead conjugation and contains the greatest number of irregularities (Bescherelle, 1981). For each irregular French verb in this study (e.g., "peindre") fewer than 27 verbs follow the same conjugation, many of which are rarely used (e.g., "aveindre", "geindre"). As is the case for English verbs, the inflection of irregular verbs requires modifying the stem, but in addition, the inflection of irregular verbs in French requires adding the phoneme [ɛ]. In sum then, for the French version, regular verbs require adding the phoneme [ε] to the stem to generate the imperfect tense (e.g., "aime-aimait"), whereas irregular verbs require modifying the stem and adding the phoneme [ε] (e.g., "boit-buvait"). Pseudo-verbs were French sounding (e.g., "codume") pronounceable non-existent verbs modeled after verbs in the first group (those that follow "aimer").

Verb Characteristics

For each language, there were 48 regular, 48 irregular, and 40 pseudo-verbs. Regular and irregular verbs were matched pair-wise on past tense frequency within and across language. Thus, for each English irregular verb, there was an English regular verb, a French irregular verb, and a French regular verb, with comparable spoken word frequency. English frequency norms were from the Associated Press Corpus and Montreal-French frequency norms from Beauchemin, Martel, and Theoret (1992). English verbs were selected from a database provided by M. Ullman. The past tense frequency for each French verb was obtained by adding the occurrence of the imperfect tense in the first, second, and third person singular, as well as in the third person plural. This was because these sound exactly the same. For instance, "je parle, tu parles, il parle, ils parlent", are all pronounced [parl]. Their imperfect tense, "je parlais, tu parlais, il parlait, ils parlaient", are homophones [parlε]. This is equivalent to how verb frequency was calculated in English, where the value for a verb (e.g., "walked") combines occurrences for several persons (e.g., "I walked, you walked, he walked, we walked, they walked"). The raw frequency of occurrence was converted to a frequency of occurrence per 1,014,232 words. This number was then natural log transformed after being augmented by 1 to avoid ln(0). For the whole set of verbs, the transformed frequencies varied between 0 and 6.9. The mean frequency was 2.4 (SD = 1.9) and 2.3 (SD = 1.8) for the English irregulars and regulars respectively, and 2.5 (SD = 1.9) and 2.6 (SD = 1.9) for the French irregulars and regulars respectively.

Sentences

The verbs were embedded into meaningful 2-sentence phrases. An example of an English phrase is: "Every day, I work on the computer. At the office yesterday I ____ on the computer." An example of a French phrase is: "Tous les soirs, Émilie chante une chanson. Son père jouait du piano hier pendant qu'Émilie ____ une chanson." The phrases were constructed such that only one tense was correct: the English sentence stem could only be completed with the past, and the French sentence stem solely with the imperfect tense. For the sentences to be meaningful, the content was allowed to vary. The structure of the phrase was kept constant such that the first sentence in the English and French version was composed of a time indicator, followed by a verb in the present tense and a complement. In the English version, the first person singular was used, whereas in the French version, the third person singular was employed. The second sentence began with a phrase, most often related to the meaning of the previous sentence, and the words "Yesterday I" or "Hier pendant que [name (e.g., Émilie)]"for the three experimental conditions. In the French version, the second sentences began with an indication that an event took place or was occurring (e.g., "Son père jouait du piano.") This is because the imperfect tense refers either to an action that took place while another event was occurring or to an action that was taking place while another event occurred. Interspersed among the experimental sentences, which all ended with the words "Yesterday I" or "Hier pendant que [name (e.g., Émilie)]", were foil sentences. These ended with "Tomorrow I will be" or "nous". The purpose of these foils was to ensure that a response could not be generated before the very end of the phrase. For the English sentence, for instance, the participant would not know whether to answer "worked" or "working" before the last few words. For the French sentence, the participant would not know whether to generate "jouait" or "jouions". In each language, there were 22 foils derived from 8 irregular verbs, 8 regular verbs, and 6 pseudo-verbs.

The phases were matched across verb type and language on the number of syllables from the first word of the sentence to the word immediately preceding the participant's response. The average number of syllables per sentence for the irregular verb, regular verb, and pseudo-verb, conditions was 14 for the English version, and 15, 15, and 14, respectively for the French version. A female native English-speaking Montrealer recorded the English sentences and a female native French-speaking Montrealer recorded the French sentences. The pace and clarity of speech as well as the amount of prosody used while recording the sentences was kept similar across the English and French versions.

Language Testing Procedure

We elected to test language in the auditory modality rather than in the visual modality. It was believed that having the participants listen to sentences would encourage them to use implicit linguistic competence in L1. Reading and writing were originally learned with effort and may not tap into implicit linguistic competence to the same extent that speech may. An exception was made for pseudo-verbs, which may be difficult to accurately perceive in the auditory modality, especially in L2, and retain in working memory. For phrases that contain pseudo-verbs, the first sentence was presented in the auditory and visual modalities. The sentences appeared at the center of the monitor in 1 cm tall X .05 cm wide medium-blue letters, against a dark purple background.

Each participant was given 11 practice trials: two with regular verbs, two with irregular verbs, three with pseudo-verbs, and four with foils. If the participant generated a verb that was different from that used in the sentence, he/she was asked to use the verb provided by the sentence. If the participant generated the wrong tense, he/she was told to use the past (or imperfect tense for the French version) and given an explanation of why the sentence structure required that tense. Participants were instructed to listen to the sentences for meaning. The sentences were presented over two speakers. The participant wore a microphone and had to say out loud the correct verb inflection immediately after hearing "yesterday I" or "tomorrow I will be" (or "hier pendant que [name]" or "hier pendant que nous" for the French version). The task was computerized and voice onset latency was recorded. For all sentences, the experimenter controlled the initiation of the phrases and of their ending. After the participant responded, a white arrow appeared on the monitor allowing the experimenter to decide whether the computer detected the participant's response as it occurred. After the participant responded, the experimenter initiated the ending of the phrase. Each participant was asked questions about the sentences throughout the test to ensure that he/she was paying attention to the meaning of the sentence rather than to the verb. The sentences were ordered randomly and the same order was used to test all participants.

Memory and Language Testing Procedure

Participants were offered the option of performing the tests in the laboratory or in their home. Two healthy older adults, five PD patients, and all AD patients elected to be tested at home. Each participant was tested over three separate days in sessions that lasted approximately 2 ½ hours each. Participants were given breaks as needed and given $45 for their participation. For each session, a native speaker administered the tests, with the exception of four young controls who were tested by a highly proficient French-English bilingual.

Memory was evaluated in each participant's L1, generally on the first day. For the memory session, the participant completed Session 1 of the mirror-reading task, followed by the learning phase of the RAVLT and BEM. Session 2 of the mirror-reading task was then carried-out, followed by the memory phase of the RAVLT and BEM. Session 3 of the mirror-reading task was then administered and the participant completed the SRT. The order of administration of the RAVLT and BEM was counterbalanced such that approximately half of the participants in each group began with the RAVLT and half with the BEM. The French and English versions of the PTG were administered on separate days for all, except three young controls. Five YC and six NC participants were tested in L2 first. Three AD patients and five PD patients were tested in L2 first, as were three NCAD and three NCPD participants. On average, the two language sessions were separated by 9 days for the YC and 9 days for the NC groups (with the exception of 154 days for one YC participant), and by 8 days for the PD group and by 10 days for the AD patients.

Apparatus and Software

Participants were tested either on a Pentium 1 IBM Thinkpad model 385XD, at study onset, or on a Dell Inspiron 5100, in the final years of the study, with each participant being tested always with the same computer. The monitor of the IBM Thinkpad measured 12 in and that of the Inspiron measured 15 in. Inquisit version 1.32 was used to run all computerized tasks (Millisecond software). Auditory stimuli were recorded using Cool Edit 2000 Software (Syntrillium Software Corporation) and presented via Dyna-Point speakers at a comfortable listening volume adjusted for each participant. A close-talk microphone headset (model Andrea NC-8) recorded the participant's responses.

Memory Results

For group comparisons, results from the NC group were compared to those from the YC group, those from the AD group to those from the NCAD group, and those from the PD group to those from the NCPD group. T-tests and ANOVAs were conducted at the .05 significance level. T-tests were one-tailed given the clear expectations for directionality. Results are reported for the declarative memory tests, i.e., the BEM and RAVLT, and then for the procedural memory tests, as in Manuscript 1.

Batterie d'Effiience Mnésieque (BEM): Scores in Table 2 represent the number of designs correctly recognized out of 24, divided by 2. Young adults recognized significantly more designs than did older adults ($t[30] = 2.01$, $p = .023$). The AD group recognized significantly fewer designs than did the NCAD group ($t[14] = 3.23$, $p < .001$), whereas the NCPD and PD group recognized a comparable number of designs ($t[16] = -0.90$, $p = .190$).

Rey Auditory Verbal Learning Test (RAVLT): Scores are reported in Table 2. T1 and T5 refer to the initial and final learning trials, respectively. Total refers to the average number of words recalled across all five learning trials. Relative to the NC group, the YC group tended to recall more words on the first learning trial, T1, ($t[30] = 1.62$, $p = .057$), and recalled significantly more words on the final learning trial, T5, ($t[30] = 2.89$, $p < .001$). The average number of words recalled across all learning trials, Total, was significantly higher for the YC group than for the NC group ($t[30] = 2.67$, $p = .006$). The NCAD group recalled significantly more words than the AD group on the T1 ($t[14] = 7.00$, $p < .001$), T5 ($t[14] = 5.76$, $p < .001$), and Total ($t[14] = 6.80$, $p < .001$), trials. In contrast, the NCPD and PD groups recalled a comparable number of words on

Table 2. *Mean scores and SEs on the BEM and RAVLT for each group*

	YC	NC	NCAD	AD	NCPD	PD
BEM (max=12)	10.75	9.56	9.88	6.38	9.56	10.22
	(.42)	(.39)	(.67)	(.85)	(.53)	(.51)
RAVLT						
T1	9.06	8.00	8.13	2.00	8.00	7.11
	(.55)	(.35)	(.61)	(.63)	(.53)	(.72)
T5	14.63	13.00	14.00	6.00	13.22	13.78
	(.20)	(.52)	(.53)	(1.28)	(.64)	(.60)
Total	64.06	57.81	59.75	21.38	58.44	53.33
	(1.47)	(1.82)	(2.76)	(4.93)	(2.57)	(2.50)
AI	14.00	11.56	12.75	3.12	11.89	10.44
	(.30)	(.66)	(.70)	(1.09)	(.90)	(1.06)
DR	14.13	11.63	12.88	3.63	11.67	11.22
	(.33)	(.55)	(.64)	(1.41)	(.71)	(.94)
DRe	14.94	14.50	14.88	8.25	14.67	14.67
	(.06)	(.20)	(.13)	(2.26)	(.17)	(.24)
FP	2.38	4.13	4.13	4.50	4.33	3.44
	(.65)	(.50)	(.79)	(1.86)	(.60)	(.65)

Note : Maximum is 15 for all RAVLT scores except for the total score out of 75. SEs are presented in parentheses. T1 = trial 1; T5 = trial 5; AI = after interference; DR = delayed recall; DRe = delayed recognition; FP = false positive errors.

the T1 ($t[16] = 1.00$, $p = .332$), T5 ($t[16] = -.64$, $p = .267$), and Total ($t[16] = 0.87$, $p = .199$), trials. AI refers to the number of words recalled from List A after interference from List B. DR refers to the number of words from List A recalled after a 30-min delay. DRe refers to the number of words correctly recognized from List A. The YC group recalled significantly more words than did the NC group, after interference (AI: $t[30] = 3.37$, $p = .001$) and after the 30-min delay (DR: $t[30] = 3.88$, $p = .001$). Relative to the NC group, the YC group also recognized more words ($t[30] = 2.05$, $p = .025$) and made fewer false positive errors ($t[30] = -2.13$, $p = .021$). The NCAD group recalled more words than the AD group after interference ($t[14] = 7.41$, $p < .001$) and after the 30-min delay ($t[14] = 5.96$, $p < .001$). The former also recognized more words ($t[14] = 2.93$, $p = .006$), but did not make fewer false positive errors ($t[14] = -.19$, $p = .428$). There was no significant difference between the NCPD and PD groups in the number of words recalled after interference ($t[16] = 1.04$, $p = .157$) or after the 30-min delay ($t[16] = .38$, $p = .355$). Similarly, both groups recognized a comparable number of words ($t[16] = .00$, $p = 1.00$) and made a similar number of false positive errors ($t[16] = 1.01$, $p = .329$).

Serial Reaction Time task (SRT): Participants made errors naming the location of the asterisk on fewer than 1% of trials, which were excluded from the analyses. Outliers, defined as 3 SDs from the mean location naming latency were removed from the data, for each participant. On average, with errors and outliers removed, 87% of the trials per block per participant remained for analysis. One AD patient was not capable of performing the task. Data from another AD patient was excluded because the number of trials that could be included in the analyses (~50% for Block 5) was judged insufficient. The average naming latency was calculated for each block for each participant. Naming latency for the final sequence-learning block, Block 4, was compared to that for the random order block, Block 5. Each participant group displayed sequence learning, as indexed by a significantly faster location naming latency for Block 4 relative to Block 5 ($t[15] = -2.38$, $p = .006$ for the YC group; $t[15] = -7.76$, $p < .001$ for the NC group; $t[5] = -2.32$, $p = .034$ for the AD group; and $t[8] = -9.71$, $p < .001$ for the PD group). The means and SEs are illustrated in Figure 1. Repeated-measures ANOVAs confirmed that the difference in naming latency between Block 4 and Block 5, was comparable for the YC and NC groups ($F[1, 30] = .24$, $p = .626$), for the NCAD and AD groups ($F[1, 11] = .19$, $p = .669$), and for the NCPD and PD groups ($F[1, 16] = .14$, $p = .717$), indicating comparable learning.

Mirror Reading: Participant errors and time failures occurred on less than 1% of triads. Outliers, defined as 3 SDs from the mean reading latency of each participant, were removed from the data. Three AD patients were not capable of performing the task. Reading latency for Repeat word triads (i.e., those that appeared in every set) was separated from that for Unique word triads (i.e., those that appeared once) in order for repetition priming and skill learning to be analyzed separately.

Repetition Priming: Reading latencies for Repeat word triads are illustrated in Figure 2. Each group displayed significant repetition priming, as evidenced by shorter reading latencies in Session 3 relative to Session 2 ($t[15] = 3.38$, $p = .002$ for the YC group; $t[15] = 2.97$, $p = .005$ for the NC group; $t[4] = 2.20$, $p = .047$ for the AD group; and $t[8] = 1.98$, $p = .042$ for the PD group) and shorter reading latencies in Session 2 relative to Session 1 ($t[15] = 2.40$, $p = .015$ for the YC group; $t[15] = 5.95$, $p < .001$ for the NC group; $t[4] = 8.78$, $p = .001$for the AD group; and $t[8] = 3.92$, $p = .002$ for the PD group).

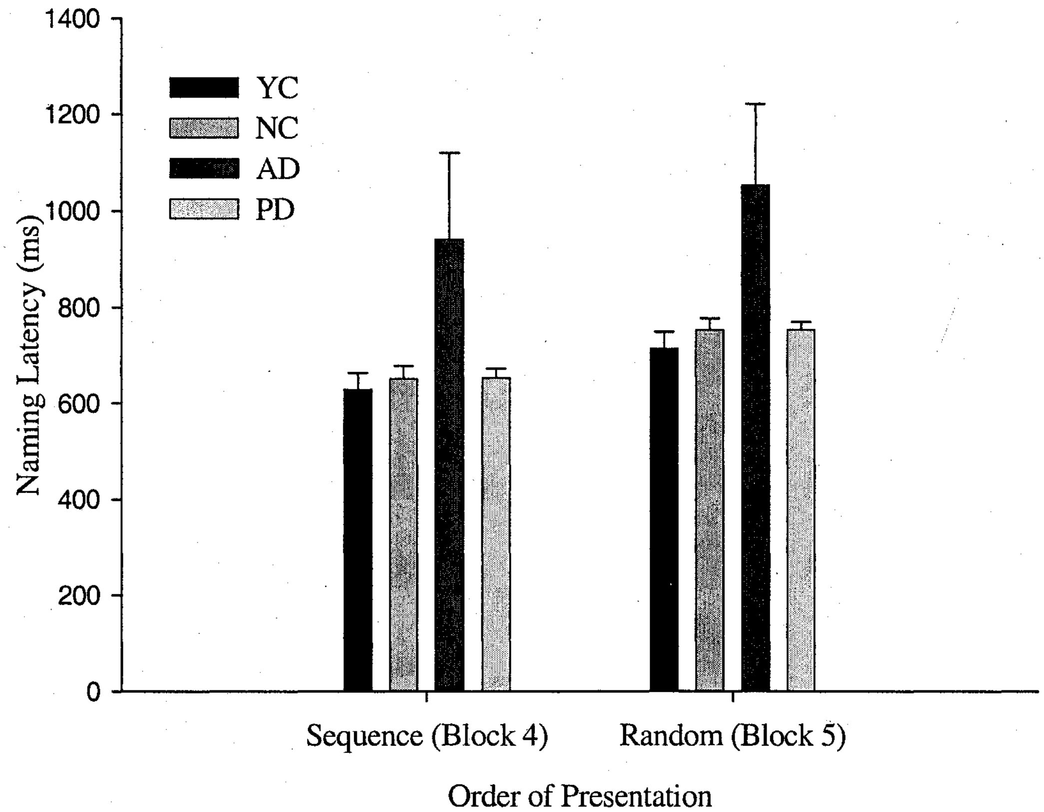


Figure 1. Latency to name the location of the asterisk, in milliseconds, for young and older adults, and for the patient groups, as a function of order of presentation of the asterisk (sequential order versus random order). Error bars represent SEs.

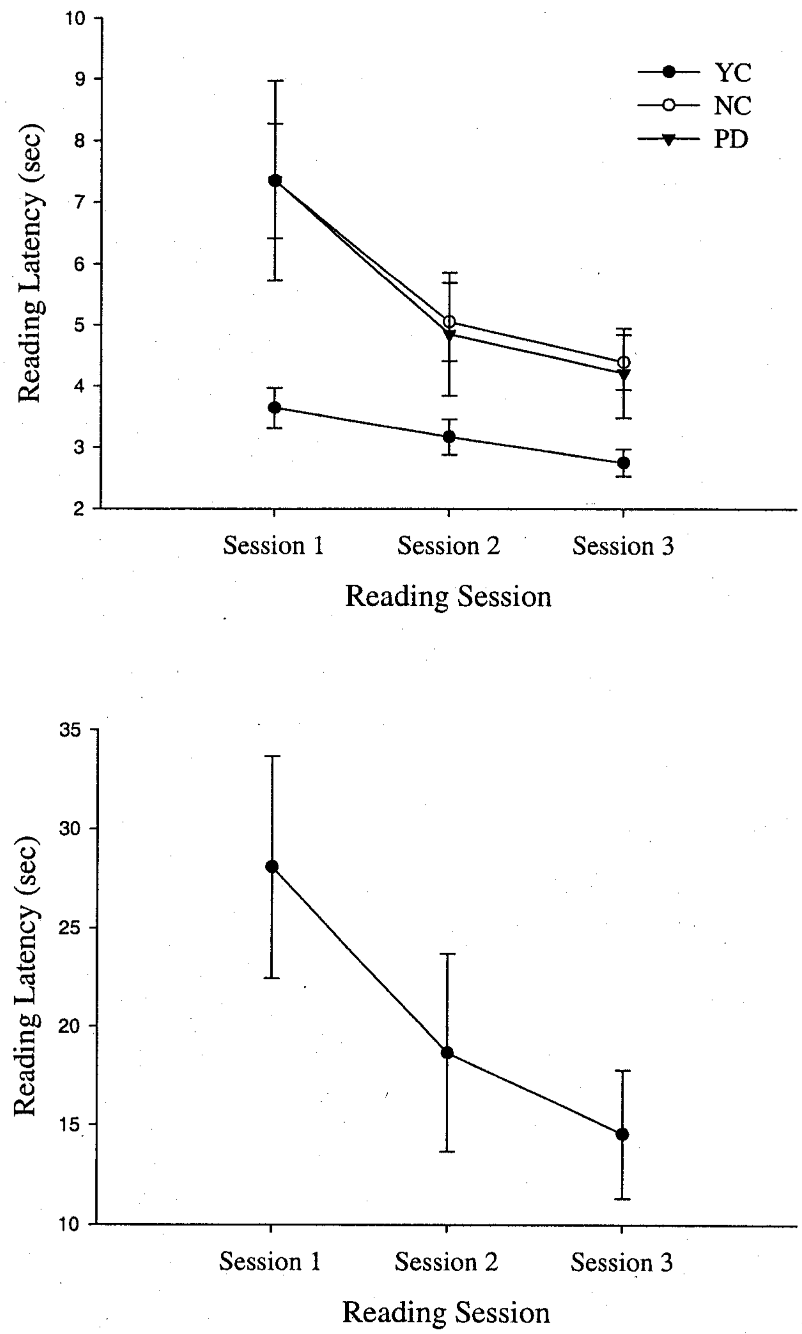
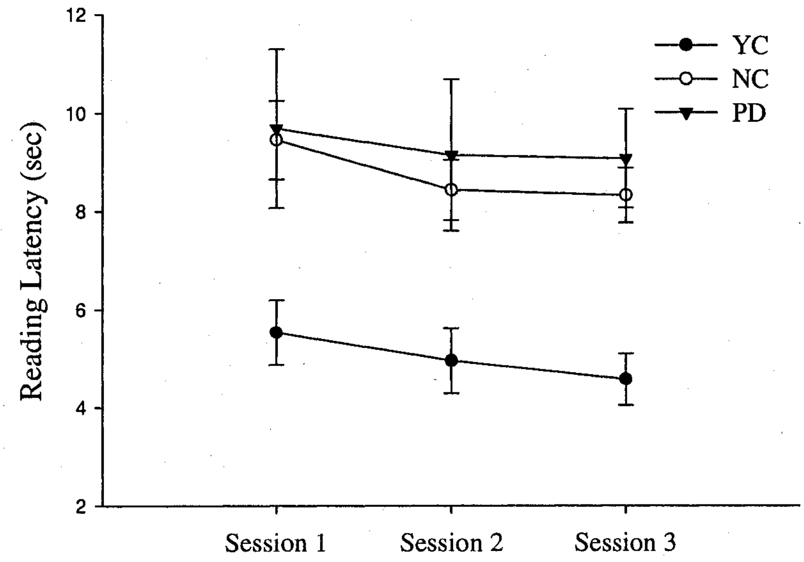


Figure 2a. Reading latency in seconds for repeat words, by reading session, for the YC, NC, and PD groups (top) and the AD group (bottom). The AD group is plotted separately due to longer latencies. Error bars represent SEs.

Repeated-measures Group X Session (1, 3) ANOVAs revealed that the effect of repetition on reading latency was larger for the NC than for the YC group ($F[1, 30] = 12.36$, $p = .001$), and larger for the AD than for the NCAD group ($F[1, 11] = 29.59$, $p < .001$). It can be noted that the NC group displayed significantly longer reading latencies than the YC group overall ($F[1, 30] = 11.49$, $p = .002$), as did the AD group relative to its control group, NCAD ($F[1, 11] = 21.23$, $p = .001$). The effect of repetition on reading latency was equivalent for the NCPD and PD groups ($F[1, 16] = .02$, $p = .880$).

Skill Acquisition: Young adults read the new word triads faster in reading session 3 than in reading session 2 ($t[15] = 2.17$, $p = .046$) and faster in reading session 2 than in reading session 1 ($t[15] = 2.41$, $p = .030$). Older adults read the new word triads faster in reading session 2 than in reading session 1 ($t[15] = 3.25$, $p = .005$), but there was no significant difference in the reading latency between sessions 2 and 3 ($t[15] = .24$, $p = .813$). These effects can be observed in Figure 2b. For the AD group, there was no significant difference in reading latency between any of the reading sessions ($t_s[6] = .68$ and .15, $p_s = .526$ and .891, for the comparison of sessions 2 and 3, and sessions 1 and 2, respectively). For the PD group, there was no significant reduction in reading latency between session 2 and 3 ($t[8] = .11$, $p = .919$), but a trend was observed toward a significant reduction in reading latency from reading session 1 to reading session 2 ($t[8] = 2.06$, $p = .074$).



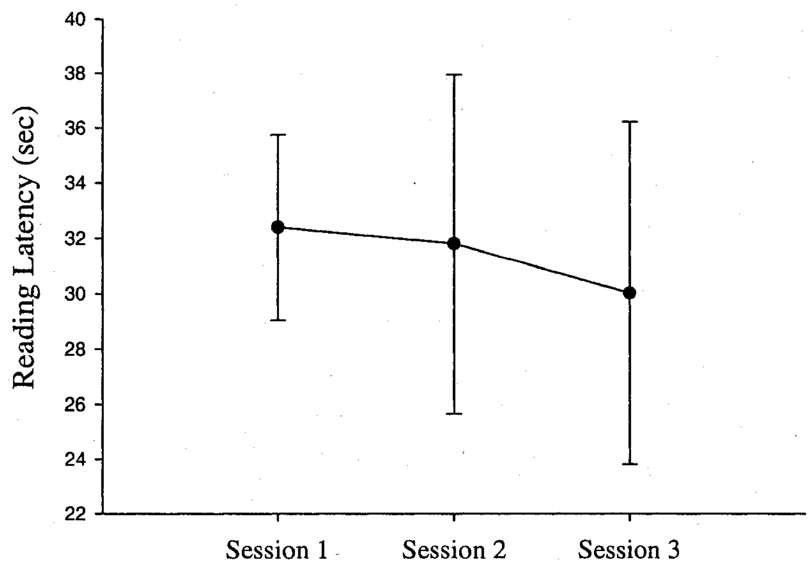


Figure 2b. Reading latency in seconds for new words, by reading session, for the YC, NC, and PD groups (top) and the AD group (bottom). Latencies for the AD group are plotted separately because they are longer.

Language Results

One AD patient was not capable of performing the PTG. The data set analyzed comprise the responses on 136 trials in total, from 48 irregular, 48 regular, and 40 pseudo-verb, trials. Only initial responses were analyzed. Only significant results or results interpreted as indicative of a trend towards statistical significance ($p < .10$) are reported. First, accuracy results are reported, followed by latency findings. The results for two global measures of accuracy are reported first, which include total errors and inflection errors. The results for specific errors, which include uninflections, irregularizations, regularizations, over-inflections, and substitutions, are reported second.

Total Errors and Inflection Errors

Two global measures of accuracy were examined: The percentage of errors in total and the percentage of inflection errors. The percentage of errors comprised every error, including answering with a verb different from the one to be inflected (e.g., answering "held" instead of "clung", after hearing "cling") or failing to answer. By contrast, inflection errors were limited to those that resulted in either an impossible form of the verb for which the past tense had to be generated (e.g., "swimmed" instead of "swam" or "dag" instead of "dug"), its unmarked inflection (e.g., "look" instead of "looked"), or another tense (e.g., "planning" instead of "planned"). The percent of total errors and inflection errors are presented in Table 3, for each participant group within each language. For each of these two accuracy measures, a repeated-measures Group X Type (Irregular, Regular, Pseudo) X Language (L1, L2) ANOVA was conducted, separately for the YC and NC comparison, the NCAD and AD comparison, and the NCPD and PD comparison.

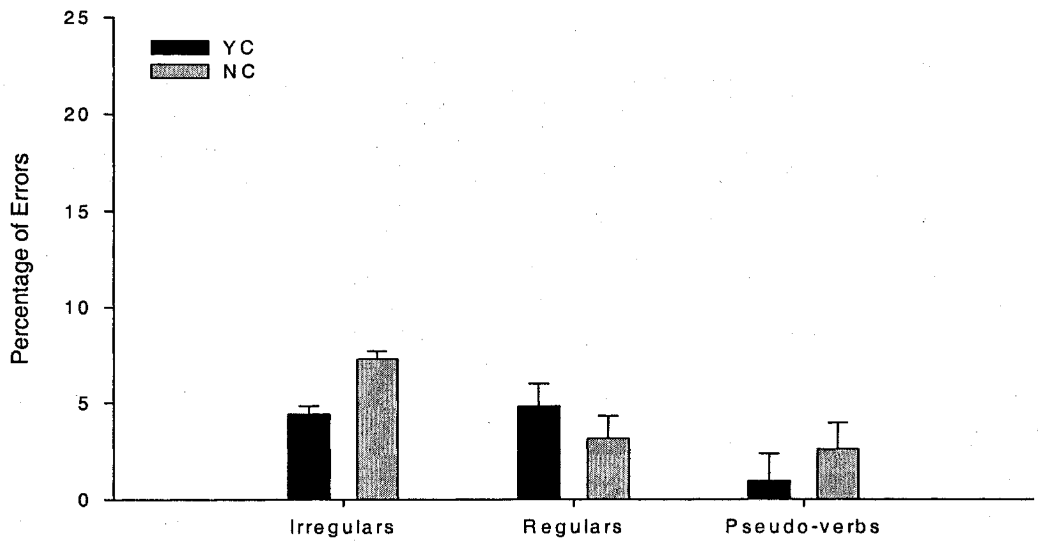
Table 3. *Percentage of errors in total and of inflection errors for each participant group, within each language.*

	Total Errors		Inflection Errors	
	L1	L2	L1	L2
YC	3.39 (.68)	8.99 (1.11)	1.08 (.17)	6.51 (1.07)
NC	4.31 (.68)	10.15 (1.11)	1.45 (.17)	7.48 (1.07)
NCAD	5.30 (1.91)	8.83 (2.80)	1.36 (.54)	6.32 (2.28)
AD	13.21 (2.04)	20.20 (2.99)	3.65 (.58)	10.40 (2.44)
NCPD	5.08 (1.16)	8.77 (2.10)	1.45 (.29)	6.74 (1.48)
PD	7.19 (1.16)	12.18 (2.10)	3.07 (.29)	8.07 (1.48)

Note: SEs are presented in parentheses.

YC and NC Comparison: The percent of total errors for each verb type, in L1 and L2, is presented in Figure 3. The results for the percent of errors in total and the number of inflection errors were comparable. There was a significant main effect of Type ($F[2, 30] = 49.86$, $p < .001$ for total errors, and $F[2, 30] = 78.41$, $p < .001$ for inflection errors) and of Language ($F[1, 30] = 44.44$, $p < .001$ for total errors, and $F[1, 30] = 52.61$, $p < .001$ for inflection errors), moderated by a significant Type X Language interaction effect ($F[2, 30] = 24.19$, $p <.001$ for total errors,and $F[2, 30] = 27.88$, $p <.001$ for inflection errors). Tukey-A post-hoc tests indicated that the percentage of errors was significantly larger for irregular verbs in L2 relative to that for any other type in L1 and L2, for total errors and for inflectional errors ($p_s < .05$). For each error measure, there was no significant main or interaction effect of Group.

NCAD and AD Comparison: The percent of total errors for each verb type, in L1 and L2, is presented in Figure 4. There was a significant main effect of Group on total errors ($F[1, 13] = 9.64$, $p = .008$), with the AD group having produced more errors overall than the NCAD group. This effect was not as apparent when the analyses were limited to inflection errors only ($F[1, 13] = 2.65$, $p = .127$). The factor Group did not interact with Type or Language. As with the YC-NC comparison, there was a significant main effect of Type ($F[2, 26] = 9.65$, $p = .001$ for total errors, and $F[2, 26] = 19.68$, $p < .001$ for inflection errors) and of Language ($F[1, 13] = 10.47$, $p = .007$ for total errors, and $F[1, 13] = 16.72$, $p = .001$ for inflection errors), moderated by a significant Type X Language interaction effect ($F[2, 26] = 11.23$, $p < .001$ for total errors, and $F[2, 26] = 10.08$, $p = .001$ for inflection errors), reflecting, again, the higher percentage of total and inflection errors for irregular verbs in L2 relative to that for any other type in L1 and L2 ($p_s < .05$).



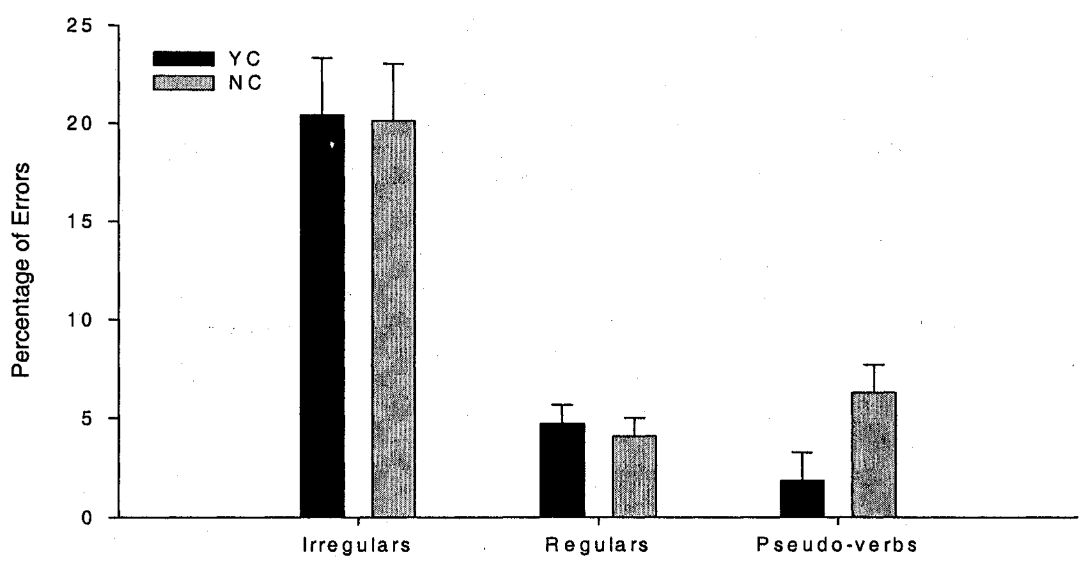


Figure 3. Percent total errors for irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the YC and NC groups. Error bars represent SEs.

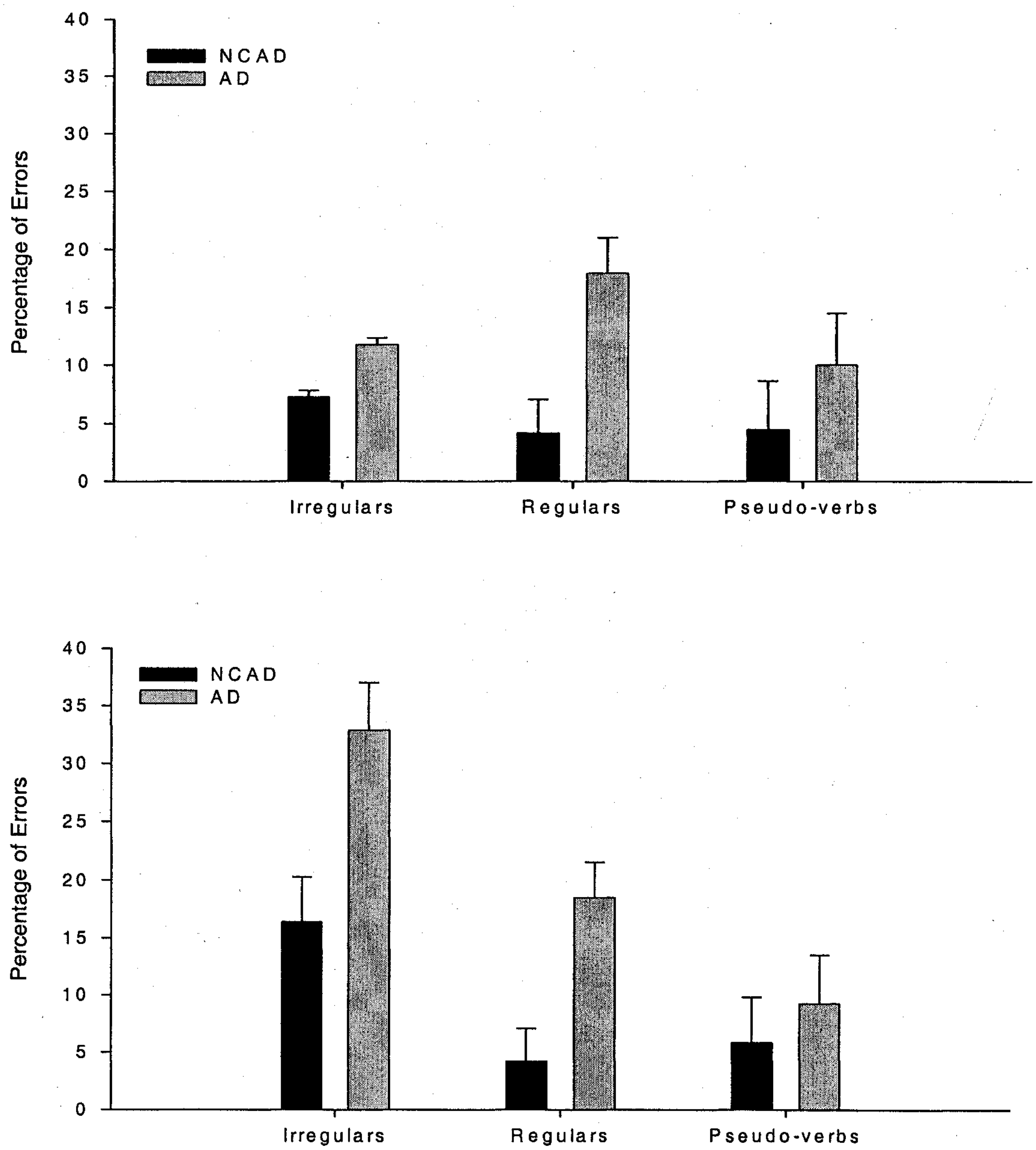


Figure 4. Percent total errors for irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the NCAD and AD groups. Error bars represent SEs.

NCPD and PD Comparison: The percent of total errors for each verb type, in L1 and L2, is presented in Figure 5. There was no significant main effect of Group on total or inflection errors, but there was a significant Group X Type interaction effect for total errors only ($F[2, 32] = 3.73$, $p = .035$). Tukey-A post-hocs revealed that PD patients made more total errors than their controls for irregular verbs only ($p < .05$). As with the YC-NC and NCAD-AD comparisons, there was a significant main effect of Type ($F[2, 32] = 35.66$, $p < .001$ for total errors, and $F[2, 32] = 44.28$, $p < .001$ for inflection errors) and of Language ($F[1, 16] = 8.49$, $p = .010$ for total errors, and $F[1, 16] = 21.56$, $p < .001$ for inflection errors), moderated by a significant Type X Language interaction effect ($F[2, 32] = 4.47$, $p = .019$ for total errors, and $F[2, 32] = 8.98$, $p = .001$ for inflection errors), reflecting the higher percentage of total and inflection errors for irregular verbs in L2 relative to any other type in L1 and L2 ($p_s < .05$). The NCPD-PD sample made significantly more total errors within L1 for irregular verbs relative to pseudo-verbs ($p < .05$). A Type X Language ANOVA conducted separately for each group indicated that this effect can be attributed to the PD group ($F[2, 16] = 2.92, 1.96$, $p = .083, 173$, for the PD and NCPD groups, respectively). Tukey-A post-hocs revealed that PD patients made more total errors inflecting irregular verbs than regular and pseudo-verbs, in L1 ($p_s < .05$).

Summary: Each group made more errors for irregular verbs in L2 than for any other verb type in L1 or L2. Aging had no effect on overall or inflection accuracy. AD patients made more errors overall than the NCAD participants, regardless of verb type and language, whereas PD patients made more errors overall than the NCPD group for irregular verbs only, irrespective of language. Within L1, the PD group made more errors for irregular verbs than for regular verbs and pseudo-verbs.

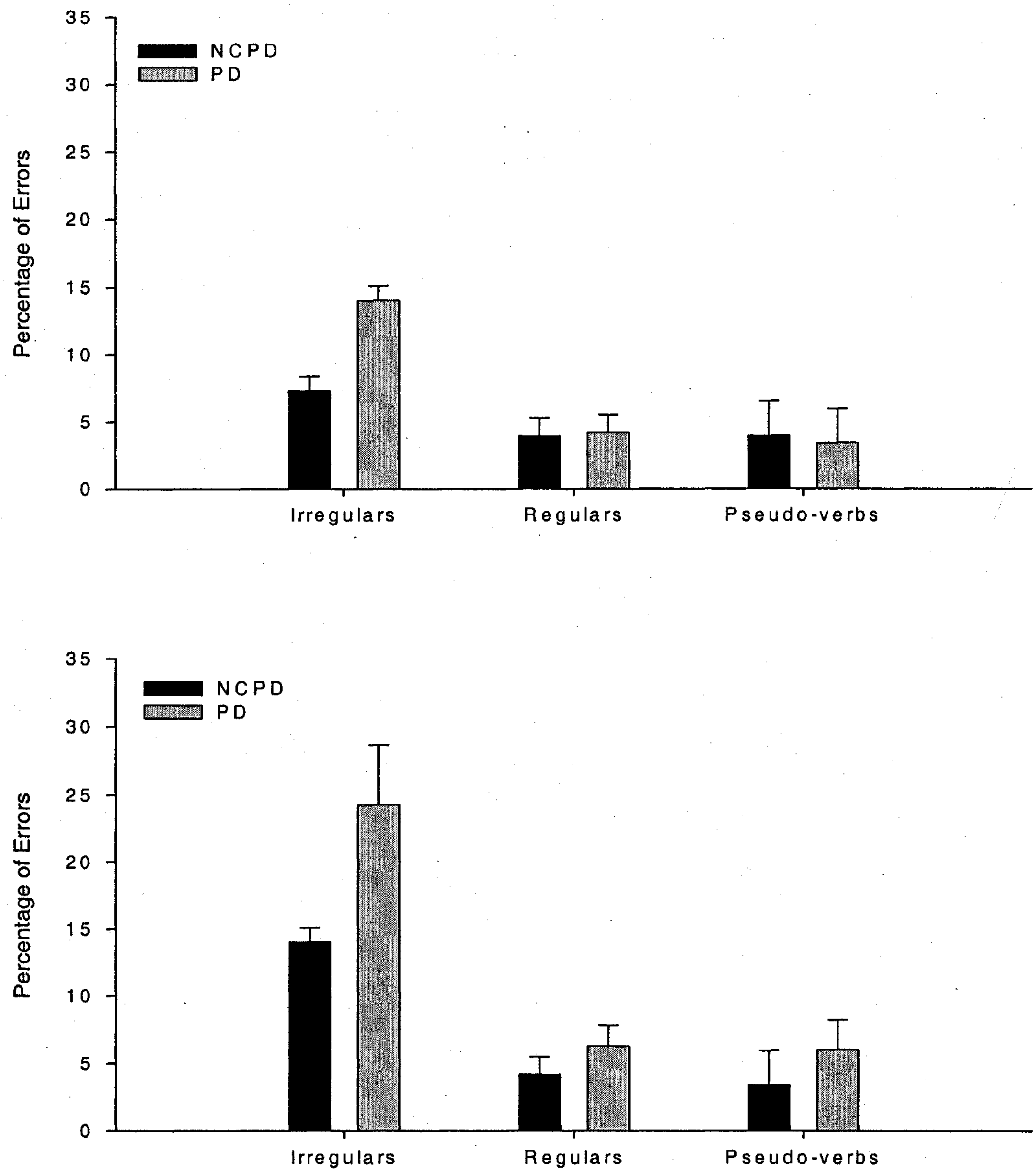


Figure 5. Percent total errors for irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the NCPD and PD groups. Error bars represent SEs.

Specific Errors

Five types of specific errors were examined, as defined below: Uninflection, irregularization, regularization, over-inflection, and substitution. Uninflections refer to the participant answering with the uninflected stem (e.g., "dig" instead of "dug" for irregular verbs; "look" instead of "looked" for regular verbs; "splaw" instead of "splawed" for pseudo-verbs). Irregularizations refer to the participant attempting to produce an irregular past tense but producing an unallowable form (e.g., "dag" instead of "dug" for irregular verbs; "lak" instead of "looked" for regular verbs). For pseudo-verbs, irregularizations refer to producing a form other than "stem + ed" (e.g., "splew" instead of "splawed", given "splaw" as the stem). Regularizations apply to irregular verbs only and refer to adding "ed" to the stem to produce the past tense (e.g., "digged"). Over-inflections were observed for irregular English verbs uniquely, and are defined as a modification of the stem plus the addition of the "ed" inflection (e.g., "dugged"). Finally, the last type of error observed, aside from failing to respond, was the participant generating the past tense of a verb different from the one to be inflected. Sometimes the participant's response was a synonym of the verb to be inflected and occasionally it had a different meaning. Of interest was whether the participant was more likely to substitute the verb to be inflected with a regular or an irregular verb. The frequency of each specific error, as a percent of the number of trials of a specific type (irregular, regular, pseudo), is in Table 4, for each group and language. A sample of the errors produced in English and French is in Table 5. Group X Type (Irregular, Regular, Pseudo) X Language (L1, L2) repeated-measures ANOVAs were conducted on the percent of uninflections (e.g., "dig"), irregularizations (e.g., "dag"), and substitutions.

Table 4. *Percent of specific errors, in L1 and L2, for each group.*

	YC	NC	AD	NCAD	PD	NCPD
L1						
Uninflections (e.g., "Dig")	.08 (.04)	.06 (.04)	1.29 (.41)	.04 (.39)	.04 (.04)	.04 (.04)
Irregularizations (e.g., "Dag")	.27 (.11)	.50 (.11)	.62 (.19)	.29 (.18)	.52 (.19)	.30 (.19)
Regularizations (e.g, "Digged")	.00 (.14)	.56 (.14)	.57 (.14)	.00 (.13)	.22 (.10)	.00 (.10)
Over-Inflections (e.g., "Dugged")	.06 (.06)	.06 (.06)	.00 (.00)	.00 (.00)	.00 (.00)	.00 (.00)
Substitution of an Irregular Verb	.56 (.14)	.50 (.14)	4.43 (.80)	.63 (.74)	.44 (.17)	.50 (.17)
Substitution of a Regular Verb	.91 (.23)	.47 (.23)	3.21 (.58)	.63 (.74)	.39 (.20)	.33 (.20)
L2						
Uninflections (e.g., "Dig")	.73 (.22)	.46 (.22)	2.53 (.43)	.58 (.40)	.74 (.26)	.59 (.26)
Irregularizations (e.g., "Dag")	1.60 (.26)	1.31 (.26)	1.52 (.57)	1.50 (.53)	1.56 (.39)	1.85 (.39)
Regularizations (e.g, "Digged")	3.56 (.98)	3.81 (.98)	2.29 (.85)	2.63 (.79)	4.56 (1.17)	2.22 (1.17)
Over-Inflections (e.g., "Dugged")	.31 (.12)	.06 (.12)	.14 (.14)	.13 (.13)	.11 (.08)	.00 (.08)
Substitution of an Irregular Verb	.47 (.17)	.50 (.17)	2.29 (.37)	.38 (.34)	.72 (.21)	.28 (.21)
Substitution of a Regular Verb	.63 (.18)	.56 (.18)	2.43 (.48)	.31 (.45)	.78 (.23)	.44 (.23)

Note: SEs are presented in parentheses.

Table 5. *Examples of each type of error, as produced by participants, in English and in French, with the correct answer provided in parentheses.*

	English	*French*
Uninflections: Participant answers with the uninflected stem.	Bend (bent) Stride (strode) Freeze (froze)	Planifie (planifiait) Répond (répondait) Vend (vendait)
Irregularizations: Participant shows attempt to irregularize by changing a letter or more in the stem or adding a letter to the stem other than "ed" in English or "ait" in French.	Cl*a*ng (clung) Forbidd*en* (forbade) S*o*ng (sang)	Cou*d*ait (cousait) Pein*t*ait (peignait) Résou*d*ait (résolvait)
Regularizations: Participant answers with the stem + "ed" in English or + "ait" in French, for an irregular verb.	Bind*ed* (bound) Swimm*ed* (swam) Teach*ed* (taught)	Mou*ait* (moulait) Bou*ait* (bouillait) Dissou*ait* (dissolvait)
Over-Inflections: Participant modifies the stem AND adds the "ed" inflection.	Bented (bent) Sented (sent) Loaned (lent)	None observed.
Other Verb — Irregular	Gave (owed)	Apprenait (étudiait)
Other Verb — Regular	Quenched (poured)	Gardait (surveillait)

Note :

Group X Language (L1, L2) repeated-measures ANOVAs were used to analyze the percent of regularizations (e.g., "digged") and over-inflections (e.g., "dugged"), since these occurred for irregular verbs only. Group comparisons were between the YC and NC groups, and between each patient group and its control group.

Uninflected stem and irregularizations

YC and NC Comparison: There was a significant main effect of Type ($F[2, 60] = 29.99$, $p < .001$ for uninflections, and $F[2, 60] = 32.58$, $p < .001$ for irregularizations) and of Language ($F[1, 30] = 10.04$, $p = .004$ for uninflections, and $F[1, 30] = 27.94$, $p < .001$ for irregularizations), moderated by a significant Type X Language interaction effect ($F[2, 60] = 10.33$, $p <.001$ for uninflections, and $F[2, 60] = 3.86$, $p = .027$ for irregularizations). Tukey-A post-hoc tests indicated that the percentage of errors was significantly larger for irregular verbs in L2 relative to that of any other Type in L1 and L2 ($p_s < .05$), for uninflected stems and for irregularizations. For each error measure, there was no significant main or interaction effect of Group.

NCAD and AD Comparison: For uninflections, there was a significant main effect of Group ($F[1, 13] = 11.76$, $p = .004$), with AD patients having left more stems uninflected than the NCAD participants. There were Type ($F[2, 26] = 4.28$, $p = .025$) and Language ($F[1, 13] = 6.87$, $p = .021$) significant main effects on uninflections, moderated by a significant Type X Language interaction effect ($F[2, 26] = 5.67$, $p = .009$). Tukey-A post-hoc tests indicated that the percentage of stems left uninflected was significantly larger for irregular verbs in L2 relative to any other Type in L1 and L2 ($p_s < .05$). For irregularizations, there was a main effect of Type ($F[2, 26] = 15.38$, $p < .001$), with more errors for irregular verbs ($p_s < .05$), and main effect of Language ($F[1, 13] = 6.43$, $p = .025$), with more errors in L2, but no main or interaction effect of Group.

NCPD and PD Comparison: Results are similar to those from the YC-NC comparison, with comparable findings for uninflections and irregularizations. There was a significant main effect of Type ($F[2, 32] = 12.80$, $p < .001$ for uninflections, and $F[2, 32] = 13.30$, $p < .001$ for irregularizations) and of Language ($F[1, 16] = 10.61$, $p = .005$ for uninflections, and $F[1, 16] = 19.90$, $p < .001$ for irregularizations), moderated by a significant Type X Language interaction effect ($F[2, 32] = 7.69$, $p = .002$ for uninflections, and $F[2, 32] = 3.44$, $p = .044$ for irregularizations). Tukey-A post-hoc tests indicated that the percentage of errors was significantly larger for irregular verbs in L2 relative to that of any other verb type in L1 and L2 ($p_s < .05$), for uninflected stems and for irregularizations.

Regularizations and Over-Inflections

For each comparison, significant results were limited to a main effect of Language, with participants making fewer regularization errors in L1 ($F[1, 30] = 22.60$, $p < .001$ for the YC-NC comparison, $F[1, 13] = 12.14$, $p = .004$ for the AD-NCAD comparison, $F[1, 16] = 14.49$, $p = .002$ for the PD-NCPD comparison). No effect of Group or Language was found for any comparison for over-inflections, which were rare.

Substitutions

Occasionally, participants answered with a verb different from the one to be inflected (e.g., hears "grasp" but answers "took"). These are not inflection errors, as there was no attempt to inflect the verb presented. With very few exceptions, these errors were limited to irregular and regular verbs. A repeated-measures Group X Type

(Irregular, Regular) X Language (L1, L2) ANOVA was conducted on the proportion of verbs substituted. For the YC-NC comparison, there were no significant effect of Group, Type, or Language. For the NCAD-AD comparison, there was a significant main effect of Group ($F[1, 13] = 47.65$, $p < .001$) and a significant Type X Language interaction effect ($F[1, 13] = 6.18$, $p = .027$), which were moderated by a significant interaction effect of Group X Type X Language interaction effect ($F[1, 13] = 8.22$, $p = .013$). Tukey-A post-hocs revealed that the AD patients substituted L1 irregulars with a different verb more often than did the NCAD group ($p < .05$). For the NCPD-PD comparison, there was a trend toward a significant Type X Language interaction effect ($F[1, 16] = 4.11$, $p = .060$), but Tukey-A post-hocs failed to clarify this effect further ($p_s < .05$).

Another interesting aspect of verb substitution is whether a group was more likely to substitute the verb to be inflected with a regular or an irregular verb. For instance, if AD patients are impaired in inflecting irregular verbs, they may substitute these with regular verbs, or if PD patients have difficulty inflecting regular verbs, they may substitute these with irregular ones. The proportion of verbs that were substituted using a regular verb was calculated for each participant as follows: The number of verbs substituted using a regular verb was divided by the total number of verbs substituted. A repeated-measures Group X Type (Irregular, Regular) X Language (L1, L2) ANOVA was conducted on the proportion verbs substituted with a regular verb. No significant results were obtained for the NC-YC comparison. For the AD-NCAD comparison, there was a trend toward a significant main effect of Group ($F[1, 13] = 3.30$, $p = .092$), with AD patients tending to substitute the verb to be inflected with a regular verb more than did the NCAD group. Again for the AD-NCAD comparison, there was a significant main effect of Type, with the participants tending to use a regular verb as a substitute for another regular verb more than as a substitute for an irregular verb ($F[1, 13] = 10.09$, $p = .007$). For the same comparison, there was a trend toward a significant Group X Type X Language interaction effect ($F[1, 13] = 3.83$, $p = .072$). Tukey-A post-hocs revealed that relative to the NCAD participants, the AD patients were more likely to substitute L1 regulars and L2 irregulars with a regular verb ($p_s < .05$). The NCAD and AD groups were equally likely to substitute L1 irregulars and L2 regulars with a regular verb ($p_s > .05$).

For the PD-NCPD comparison, only a trend toward a significant main effect of Language was found ($F[1, 16] = 3.39$, $p = .084$), suggesting that the NCPD and PD participants as a group were more likely to substitute the verb to be inflected with a regular verb in L2 than in L1. A Type X Language ANOVA was conducted separately for each group and replicated the effect for the PD ($F[1, 8] = 3.52$, $p = .097$) but not the NCPD group ($F[1, 8] = .138$, $p = .720$).

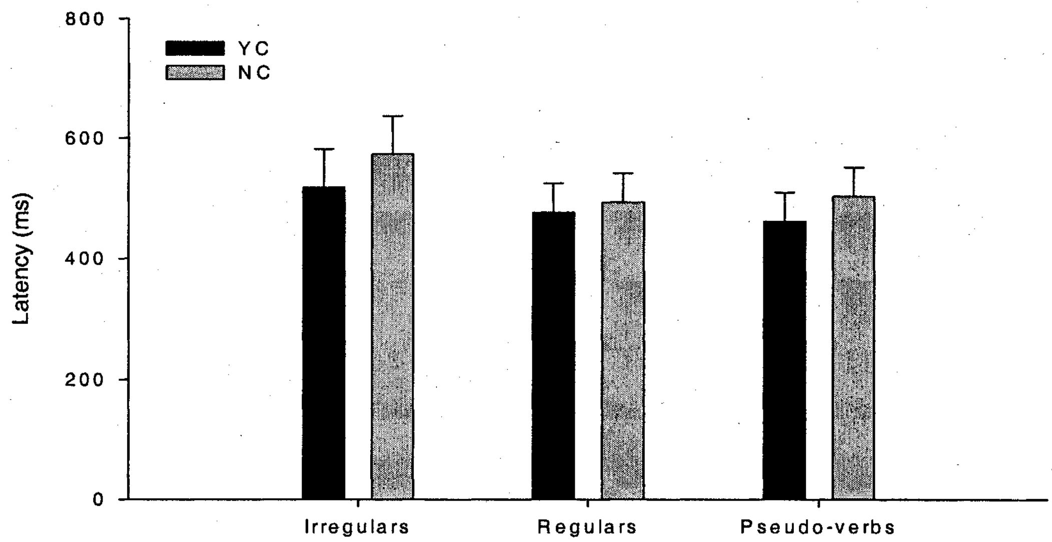
Summary: The most common type of error was the regularization of irregular verbs in L2 (e.g., "swimmed"). All participants made more uninflection (e.g., "bend") and irregularization (e.g., "s*o*ng") errors for irregular verbs in L2 relative to any other condition, and AD patients left more stems uninflected than NCAD participants. There was no effect of group or language on over-inflections, but these occurred rarely. Young and older adults substituted the verb to be inflected equally often. By contrast, AD patients were more likely to substitute L1 irregulars with a different verb, and to specifically replace L1 regulars or L2 irregulars with a regular verb. PD patients appeared more likely to substitute the verb to be inflected with a regular verb in L2 than in L1.

Overall Summary of Accuracy Results: Each group made more errors for L2 irregulars, and the most typical error was regularization (e.g., "teached"). Young and older adults did not differ on accuracy. Relative to their controls, AD patients made more errors overall, regardless of type and language. The AD group left more stems uninflected. They were more likely to substitute L1 irregular verbs with another verb, and to substitute L1 regulars or L2 irregulars with a regular verb. Relative to their controls, the PD group made more errors for irregular verbs only. Within L1, PD patients made more errors for irregular verbs than for regular or pseudo-verbs. They did not differ from their healthy counterparts on specific error measures, but were more likely to replace the verb to be inflected with a regular verb in L2.

Past Tense Generation Latency

Trials that did not accurately measure past tense generation latency were excluded from the analyses. These include trials on which the participant produced an error, and trials on which the computer either detected a sound other than the participant's response or failed to detect a response. Outliers, defined as 3 SDs from each participant's mean latency, were excluded from the analyses. On average, 10.0% ($\underline{SD}$ = 9.9) and 17.4% ($\underline{SD}$ = 11.9) of trials were excluded from L1 and L2 data, respectively. First, the effect of Group, Type, and Language on response latency was examined through repeated-measures Group X Verb Type (Regular, Irregular, Pseudo) X Language (L1, L2) ANOVAs conducted on the full data set. Second, the effect of verb past tense frequency on response latency was investigated by conducting repeated-measures Group X Type (Regular, Irregular) X Language (L1, L2) X Frequency (Low, High) ANOVAs on a subset of verbs selected to be of high frequency or low frequency. Separate ANOVAs were ran for each group comparison: YC-NC, NCAD-AD, and NCPD-PD. Finally, the correlation between verb past tense frequency and response latency was examined for each group within each verb type and language. The effect of group, type, and language, are described first, followed by the effect of verb frequency.

YC and NC Comparison: The latency to inflect each verb type, in L1 and L2, is depicted in Figure 6. There was no significant main effect or interaction effect of Group. There was a significant main effect of Language ($\underline{F}[1, 30] = 17.87$, $\underline{p} = .000$), with faster verb generation latencies for L1 relative to L2, as well as a main effect of Type ($\underline{F}[2, 60] = 5.32$, $\underline{p} = .007$). Tukey-A post-hocs revealed that participants took longer to inflect irregular verbs than to inflect regular or pseudo-verbs ($\underline{p}_s < .05$).



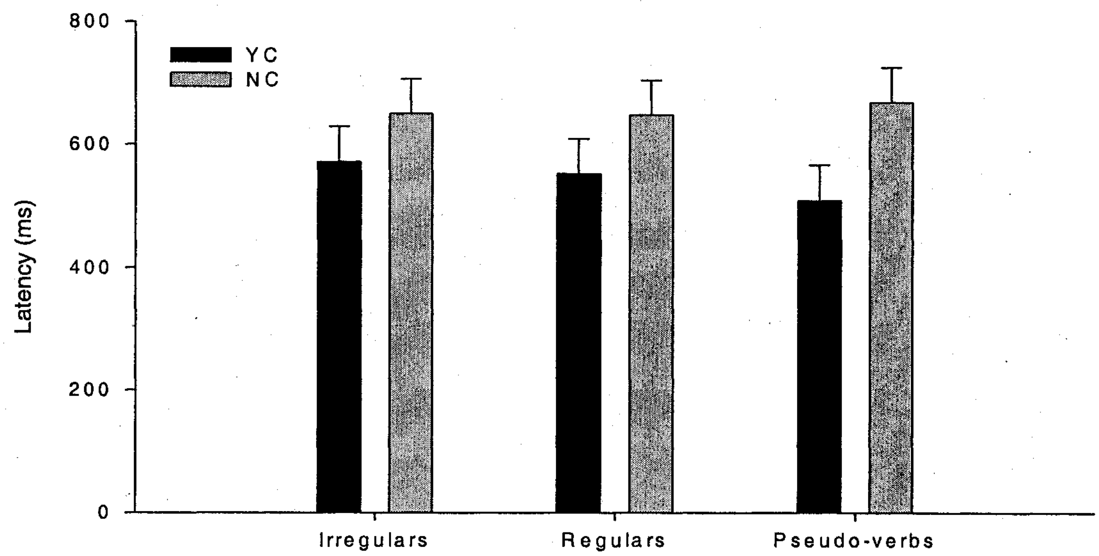


Figure 6. Latency to inflect irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the YC and NC groups. Error bars represent SEs.

NCAD and AD Comparison: The latency to inflect irregular verbs, regular verbs, and pseudo-verbs, in L1 and L2, is depicted in Figure 7. There was a trend toward a significant main effect of Group, suggesting that the NCAD participants responded faster than the AD patients ($F[1, 12] = 3.92$, $p = .071$). Group did not significantly interact with any of the within-subjects factors. There were no significant main effects of Type or Language, but a significant Type X Language interaction effect was found ($F[2, 24] = 6.12$, $p = .007$). Within L1, participants generated the past tense of regular verbs faster than that of irregular ones ($p < .05$). Irregular verbs were inflected equally fast in L1 and L2, while regular verbs were inflected faster in L1 than in L2 ($p < .05$). Again within L1 only, pseudo-verbs, were inflected faster than irregular verbs ($p < .05$), but not than regulars verbs ($p > .05$). These findings were replicated within the AD sample alone (Type X Language: $F[2, 10] = 4.15$, $p = .049$), but not within the NCAD sample alone (Type X Language: $F[2, 14] = 1.81$, $p = .200$), and Tukey post-hocs confirmed that AD patients generated the past tense of regular verbs faster than that of irregular verbs, within L1 only ($p < .10$).

NCPD and PD Comparison: The latency to inflect irregular verbs, regular verbs, and pseudo-verbs, in L1 and L2, is depicted in Figure 8. Results from this data set mirror those from the YC and NC comparison. There was no significant main effect or interaction effect of Group. There was a significant main effect of Language ($F[1, 16] = 4.94$, $p = .041$), with faster verb inflection in L1 relative to L2. There was a trend toward a main effect of Type ($F[2, 32] = 2.72$, $p = .081$), and Tukey-A post-hocs suggested that participants may have taken longer to generate the past tense of irregular verbs than to generate that of regulars ($p_s < .10$).

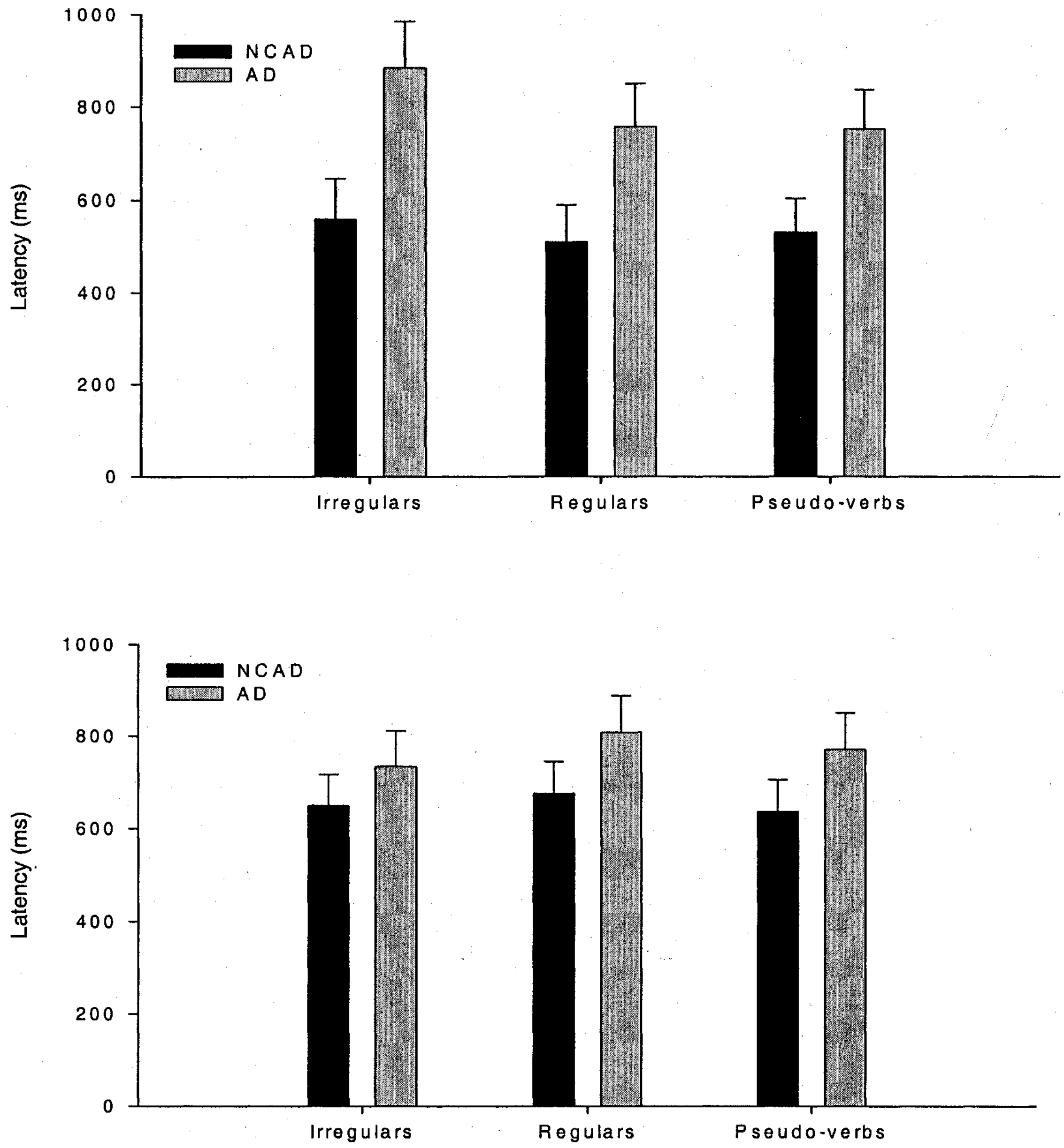


Figure 7. Latency to inflect irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the NCAD and AD groups. Error bars represent SEs.

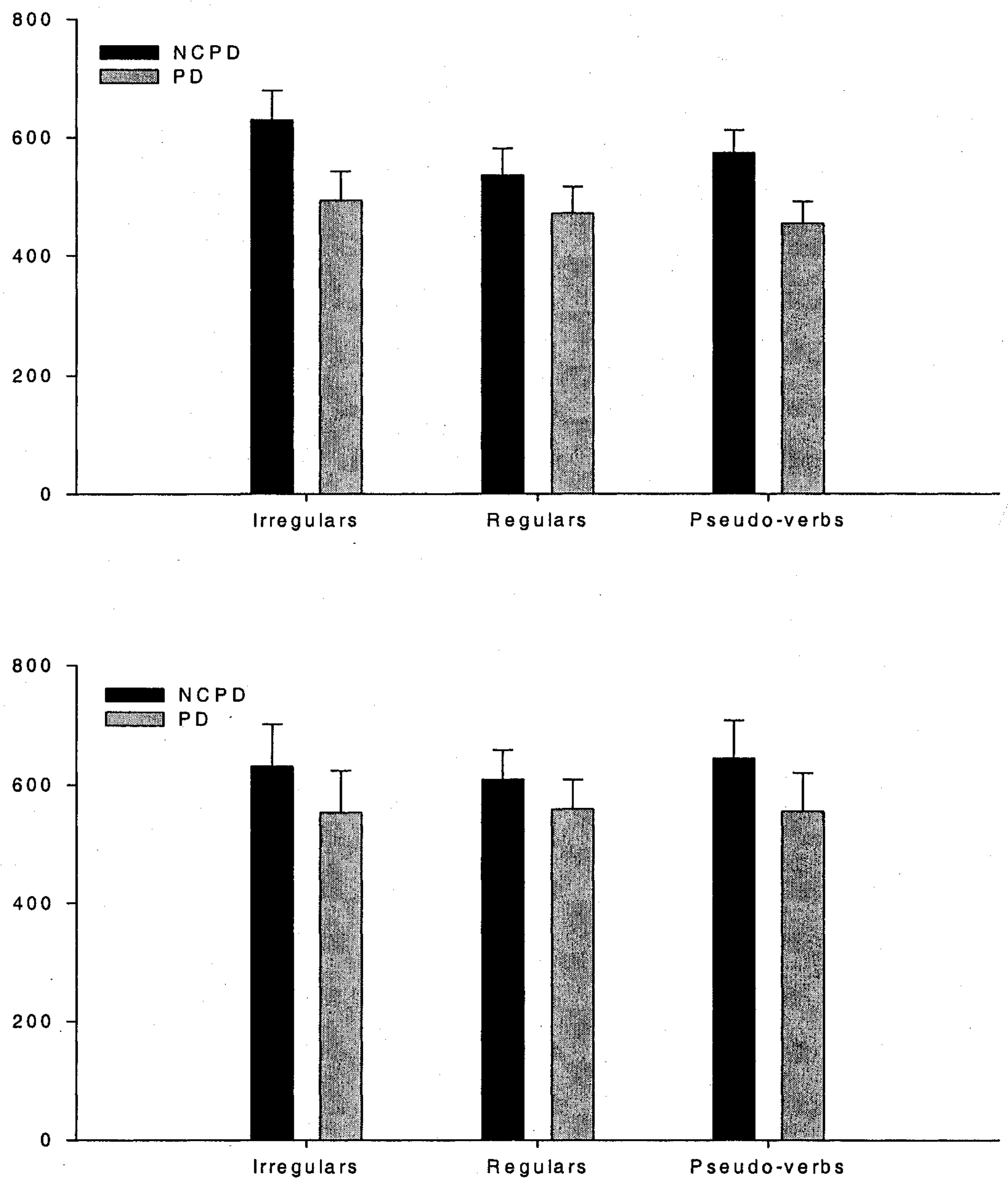


Figure 8. Latency to inflect irregular, regular, and pseudo-verbs, in L1 (top) and L2 (bottom), for the NCPD and PD groups. Error bars represent SEs.

Summary: YC and NC participants did not differ on latency to generate the past tense of verbs, nor did NCPD and PD participants. All displayed shorter verb generation latencies for L1 relative to L2, and for regular verbs relative to irregular ones. AD patients were slower than NCAD controls to produce a response, regardless of verb type of language. AD patients inflected regular verbs faster than irregular ones, in L1 only.

Frequency Effects

A subset of 22 low-frequency and 18 high-frequency verbs were selected from the pool of 48 irregular verbs, and from the set of 48 regular verbs. Low-frequency irregular and regular verbs have a mean past tense frequency of 1.1 and 1.2 respectively, for each the English and French versions. High-frequency irregular verbs have a mean past-tense frequency of 4.1 and 4.0 for the English and French versions, respectively. High frequency regular verbs have a mean past-tense frequency of 3.9 and 4.0 for the English and French versions, respectively. Repeated-measures Group X Type (Regular, Irregular) X Language (L1, L2) X Verb Frequency (Low, High) ANOVAs were conducted on past tense generation latency. Separate ANOVAs compared the performance of the NC group to that of the YC participants, that of the AD group to the performance of the NCAD controls, and data from the PD patients to that from the NCPD group.

YC and NC Comparison: There was no significant main effect or interaction effect of Group. There was a significant main effect of Language ($F[1, 30] = 10.51$, $p = .003$), modified by a significant Language X Frequency interaction effect ($F[1, 30] = 7.44$, $p = .011$). Tukey-A post-hoc tests revealed that in L2, the participants took longer to inflect low-frequency verbs than to inflect high-frequency verbs ($p < .05$). In L1, frequency had no effect on past tense generation latency ($p > .05$). Finally, consistent with results from the Group X Type X Language ANOVA, a main effect of Type was observed ($F[1, 30] = 7.16$, $p = .012$), as reflected in a shorter inflection latency for regular verbs relative to irregular ones.

NCAD and AD Comparison: There was a trend toward a significant main effect of Group ($F[1, 12] = 3.54$, $p = .084$), with the patient group likely displaying longer past tense generation latencies. A trend was observed toward a significant Group X Frequency interaction effect ($F[1, 12] = 3.54$, $p = .084$), with NCAD participants being faster than the AD patients at generating the past tense of high-frequency verbs ($p < .05$), but not that of low-frequency verbs ($p > .05$). This effect is illustrated in Figure 9. There were no significant main effects of Type, Language, or Frequency, and no other interaction effect of Group, but a significant Type X Language interaction effect was observed ($F[1, 12] = 14.42$, $p = .003$). Just as was found for the Group X Type X Language ANOVA reported previously, Tukey-A post-hocs revealed that regular verbs were inflected faster in L1 than in L2, but that language had no effect on the latency to inflect irregular verbs ($p < .05$).

NCPD and PD Comparison: There was no significant main effect of Group ($F[1, 16] = 1.60$, $p = .225$), but there was a trend toward a significant main effect of Type ($F[1, 16] = 3.10$, $p = .098$), and a significant Group X Type interaction effect ($F[1, 16] = 6.29$, $p = .023$). As illustrated in Figure 10, the NCPD participants generated the past tense of regular verbs faster than that of irregular verbs ($p < .05$), whereas for the PD patients, there was no significant difference in the verb generation latency for regular and irregular verbs ($p > .05$). (Note: This result is different from that obtained for the Group X Type X Language ANOVA, in which the Group X Type interaction effect did not reach statistical significance [$F(2, 32) = 1.88$, $p = .170$]. However, the Group X Type X Language ANOVA was conducted on data from 136 trials [48 irregular, 48 regular, 40 pseudo-verbs], whereas the current ANOVA was conducted on 80 data points

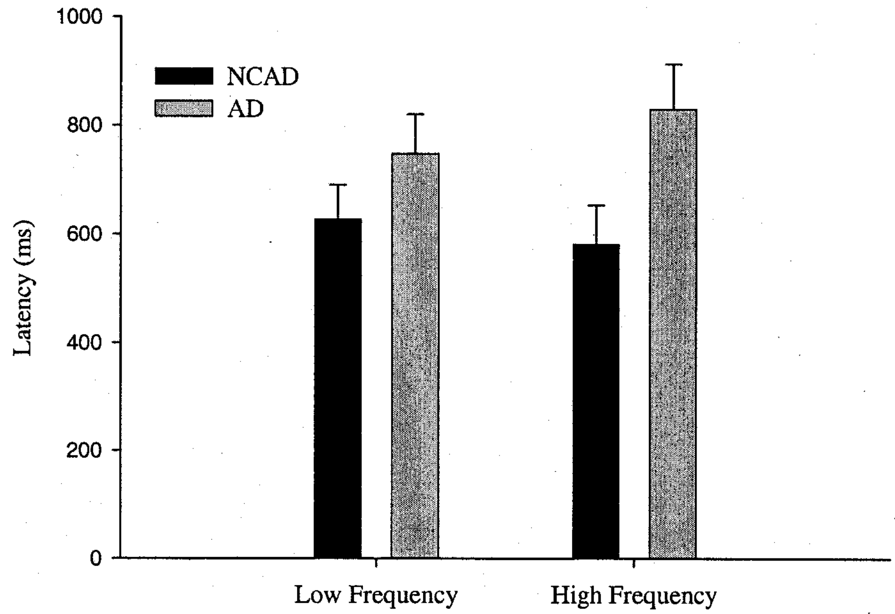


Figure 9. Latency to inflect low-frequency and high-frequency verbs, for the NCAD and AD groups. Error bars represent SEs.

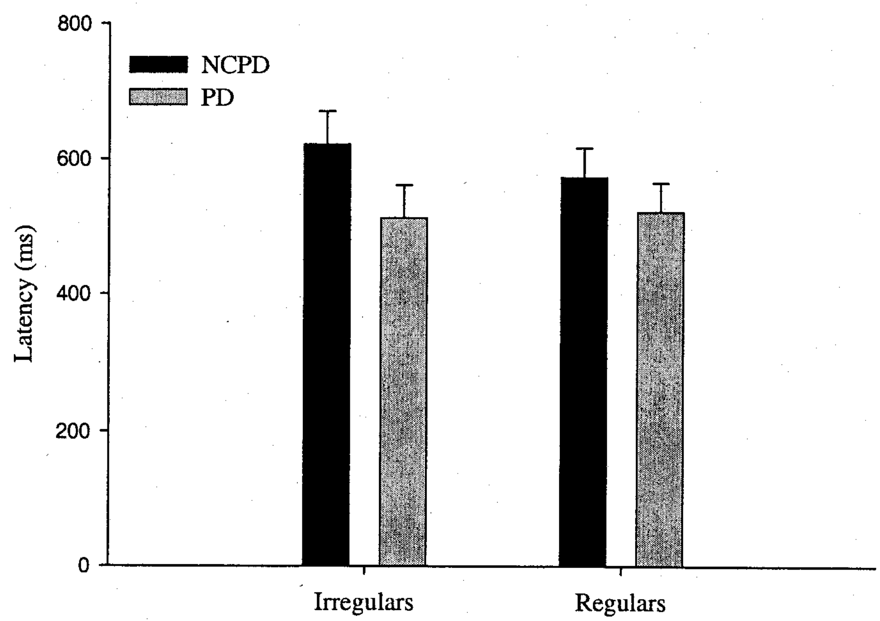


Figure 10. Latency to inflect irregular and regular verbs, for the NCPD and PD groups. Error bars represent SEs.

[22 high-frequency and 18 low-frequency verbs, for the irregular and for the regular type condition]). A trend toward a main effect of Language ($F[1, 16] = 3.42$, $p = .083$), and toward an interaction effect of Language X Frequency ($F[1, 16] = 4.13$, $p = .059$), was observed, moderated by a significant interaction effect of Type X Language X Frequency ($F[1, 16] = 5.00$, $p = .040$). Tukey-A post-hocs indicated that the latency to inflect low-frequency regular verbs in L1 was shorter than the latency to inflect high and low frequency, regular and irregular verbs, in L2. It was also shorter than the latency to generate the past tense of low-frequency irregular verbs in L1. This effect was replicated in separate analyses within the NCPD group (Type X Language X Frequency: $F[1, 8] = 7.50$, $p = .025$), but not within the PD group (Type X Language X Frequency: $F[1, 8] = .660$, $p = .440$).

Summary: YC and NC participants inflected high-frequency verbs faster than low-frequency verbs, in L2 only. AD patients were as fast as their controls in inflecting low-frequency verbs, but were slower than the NCAD group at inflecting high-frequency verbs. For the PD-NCPD comparison, a significant difference emerged, which had not been apparent in the Group X Type X Language ANOVA: PD patients inflected regular and irregular verbs equally fast, whereas the NCPDs inflected regular verbs faster than irregular verbs. The NCPD group inflected L1 low-frequency regular verbs faster than other verb types, but not PD patients.

Correlational Analyses: A complementary method to examine frequency effects is to examine the correlation between past tense frequency and response latency. Separate correlations were computed for each participant group, within each verb type and language condition. The correlations were computed for French L1 and English L2, since the majority of participants were French native speakers. Pearson's r was computed between past tense frequency and latency. All tests of significance are one-tailed since latency was expected to decrease with increasing past tense frequency. The results are reported in Table 9. Comparable results were obtained with stem frequency controlled for. In short, the YC group showed a significant negative correlation between verb frequency and latency, for irregular verbs, in L1 and L2. The NC group showed a trend toward a significant negative correlation between verb frequency and latency, for irregular verbs, in L1. The patient groups did not display frequency effects.

Table 9. *Correlation coefficients and probability levels of correlations between past tense frequency and verb tense generation latency, for the YC, NC, AD, and PD groups.*

		L1 Irregulars (French)	L1 Regulars (French)	L2 Irregulars (English)	L2 Regulars (English)
YC	n = 13	r (48) = -.33 *p = .012**	r (48) = -.06 p = .343	r (48) = -.28 *p = .026**	r (48) = -.08 p = .287
NC	n = 13	r (48) = -.19 *p = .095~**	r (48) = .12 p = .200	r (48) = -.15 p = .157	r (40) = -.07 p = .327
AD	n = 6	r (48) = -.12 p = .226	r (48) = .15 p = .163	r (47) = .03 p = .419	r (47) = -.06 p = .357
PD	n = 7	r (48) = -.16 p = .142	r (48) = .11 p = .238	r (48) = -.17 p = .122	r (40) = -.12 p = .212

Discussion

Memory and Language in Aging: The BEM and RAVLT recruit episodic aspects of declarative memory, as participants must remember the words and designs presented during the learning episode. As expected, since episodic memory has been shown to decrease with aging (Flicker et al., 1986), older adults remembered fewer designs and words than did younger adults, on the BEM and RAVLT, respectively. By contrast, aging had no effect on procedural memory, as shown by the fact that the older group performed similarly to the younger group in both the visual and verbal modalities, i.e., on the SRT and mirror-reading tasks. For each group, performance on these two tests improved with repetition. The performance of the older group is thus consistent with procedural memory being relatively immune to the effect of aging (Smith & Fullerton, 1981). The magnitude of the repetition priming effect on the mirror-reading task was larger for the older group than for the younger one. Similar age-related increases in priming effects have been attributed to the fact that populations with longer reaction times can benefit more from priming (Giffard et al., 2003). As the older group displayed significantly longer reading latencies overall than the younger one on the mirror-reading task, it is likely that the observation of greater repetition priming in older adults reflects their slower reading speed.

The inflection of irregular verbs and L2 regular verbs is posited to depend on the semantic aspects of declarative memory, and the inflection of L1 regular verbs on procedural memory. Since aging affects mostly the episodic aspects of declarative memory (i.e., memory for temporally dated episodes) rather than its semantic aspects (i.e., memory for facts, concepts, and vocabulary; Flicker et al., 1986), and spares procedural memory (Smith & Fullerton, 1981), past tense generation was expected to be relatively immune to the effects of aging. The results strongly support this hypothesis. Aging did not significantly affect the accuracy measures of verb inflection, nor the latency measures. The performance of the YC group on the PTG was 97% accurate in L1 and 91% accurate in L2, and that of the NC group was 96% accurate in L1 and 90% accurate in L2. The performance of older adults was similar to that of young controls in every respect, and the level of accuracy observed in the NC group in L1 approximates that reported by Ullman et al. (1997).

For healthy participants, regardless of age, verb type did not have an effect on accuracy in L1: Errors in producing the past tense of irregular verbs, regular verbs, and pseudo-verbs, were equally rare. It is possible that failure to observe an effect of verb type or of age on the ability to correctly inflect L1 verbs is due to a ceiling effect in the performance of healthy subjects. This ceiling effect could not be avoided. If verbs so rare as to not be known by most people had been selected, accuracy scores would be lower but not meaningful nor informative. By contrast, verb type had a significant effect on accuracy in L2, with participants making more errors for irregular verbs than for regular verbs and pseudo-verbs. This finding may appear inconsistent with the hypothesis that the past tense of both irregular verbs and L2 regular verbs is retrieved from declarative memory. If this were the case, we would expect comparable rates of declarative memory failures for regular and irregular verbs in L2. However, the past tense of irregular verbs may require more memorization than that of regular verbs. For instance, a student learning English as an L2 needs to spend more time studying the list of exceptions than the list of regular verbs. As such, the past tense of irregular verbs may be more vulnerable to forgetting than that of regular verbs, contributing to the difference in accuracy between the irregular and regular verb conditions in L2. Although most participants reported using their L1 and L2 equally often, most have had further educational and conversational experience with their L1. It is possible that for some of the L2 irregular verbs, the participants had never learned the correct past tense form, partly explaining the reduced accuracy for irregular verbs in L2 but not in L1. The commonest type of error was the regularization of irregulars in L2 (e.g., "swimmed"). This type of response is compatible with the participant applying the "+ed" rule after having failed to retrieve the correct past tense form from declarative memory.

In short, the accuracy data suggests that aging does not affect the exactness with which adults inflect verbs to mark tense. Naturally, older adults have had more experience with language than a younger cohort, and may be able to compensate for an age-related decrement. As such, the specific processes underlying past tense generation in young and older adults may be qualitatively or quantitatively different but result in the same response, as measured by inflection accuracy. In this respect, latency measures can provide complementary information.

The overall latency results are similar to the accuracy results. Age did not have a significant effect on latency. Verb type affected latency in L2 only, with participants taking longer to inflect irregular verbs than to inflect regular or pseudo-verbs. Together, the accuracy or latency results suggest that the past tense of irregular verbs in L2 were generated somewhat differently than that of other verbs. It may be that rather than retrieving the past tense of L2 irregular verbs from declarative memory as an entry, the participants retrieved the "+ed" rule from declarative memory and applied it declaratively. This would have resulted in longer latencies and higher frequency of regularization errors as observed in the healthy adults.

It is well-documented that high frequency words are retrieved from declarative memory faster than low frequency ones. Thus, if the past tense of a verb is retrieved from declarative memory, as posited for irregular verbs and L2 regular verbs, then an effect of past tense frequency on latency should be seen. By contrast, if the past tense of a verb is generated productively, as is posited for L1 regular verbs, then frequency effects should not be observed, since implementing the "+ ed" procedure proceeds at the same pace regardless of specific verb characteristics, including frequency. There are two major ways to test the effect of verb frequency on verb inflection. One is to compare the mean latency to generate high-frequency past tenses to the mean latency to generate low-frequency past tenses. A second way is to is to test the statistical significance of the correlation between past tense frequency and latency to generate the past tense. The two methods can yield complementary information. Using the first method, frequency effects were observed in L2 only, with high-frequency past-tenses having been generated faster than low-frequency ones. Within L1, frequency did not affect inflection speed. These results suggest that past tense generation recruits declarative memory to a greater extent in L2 than in L1, at least in young and older healthy bilinguals who for most have learned their L2 after puberty. This conclusion is consistent with Paradis' and Ullman's posit that an L2 learned after puberty relies more on declarative memory and its neuroanatomical substrate, relative to an L1.

Using the second method, frequency effects were observed for irregular verbs, in L1 and in L2, with past tense being retrieved faster as past tense frequency increases, within the young group. This supports the hypothesis that the past tense of irregular verbs is retrieved from declarative memory. For regular verbs in L1, frequency effects were not observed, consistent with the hypothesis that the past tense of L1 regulars is generated productively. However, no significant frequency effect was observed for regular verbs in L2. This finding fails to demonstrate that the past tense of regular verbs in L2 is retrieved from declarative memory as an entity, in the same way as that of irregular verbs is. This does not rule out that that declarative memory is involved in generating the past tense of L2 regular verbs, since participants may have applied the "+ed" rule declaratively. But, unless implementing a procedure takes the same time as declaratively applying a rule, we would expect a difference in past tense generation latency between the L1 and L2 regular verb conditions. This difference was not observed. Finally, within the older group, a trend toward a negative correlation between past tense frequency and latency was observed for irregular verbs in L1 but not in L2. This age-related difference, with younger adults displaying a significant frequency effect in the L2 irregular verb condition but not older adults, could reflect a change in the structure of declarative memory or in the processes used to generate the past tense of verbs. It is not possible to know whether the changes are qualitative or quantitative, or to specify their nature. In this respect, measures with superior time resolution, such as event-related brain potentials, or spatial resolution, such as brain imaging measures, could guide the understanding of the extent to which the declarative memory system or procedural memory system circuitries were involved for each population, verb type, and language.

Memory and Language in AD: As expected since declarative memory deficits are a hallmark of AD, the AD group displayed clear deficits on the tests of declarative memory. AD patients were impaired in learning a list of simple common words, and in recognizing these words, on the RAVLT. The patient group was also impaired within the visual modality, as evidenced by the fact that they recognized significantly fewer designs than their controls. By contrast, AD patients were able to benefit as much as their healthy counterparts from repetition on the SRT and mirror-reading task. The magnitude of the repetition priming effect on the mirror-reading task was larger for the AD patients than for their healthy counterparts. This is similar to how the magnitude of the same effect was greater for the older group relative to the younger one, and may be attributable to the fact that AD patients displayed longer reading latencies than their controls overall. Whereas as a group, the AD patients who completed the SRT and mirror-reading task displayed procedural learning, one AD patient was not able to complete the SRT and three AD patients were unable to complete the mirror-reading task. To perform on the SRT, the participant must be able to remember four locations and understand and remember that the task is to name the location where the asterisk appears. The patient who did not complete the test was unable to understand and remember the instructions. To complete the mirror-reading task, the participant had to identify the letters and retrieve from lexical memory a word that matches the visual input. To avoid a ceiling effect in the healthy participants, the mirror-reading words were selected to be of low frequency. The three AD patients who were not able to complete the task seemed unable to retrieve these words from lexical memory. We nevertheless believe, based on the group results on the SRT and mirror-reading tasks, that the AD patients had relatively well preserved procedural memory and that those patients who failed to complete the tasks did so because of working memory restrictions and lexical memory limitations rather than because of procedural memory restrictions. In sum, the memory findings for AD patients are indicative of good procedural memory in the context of impaired declarative memory, suggesting impairments in medial temporal lobe function with relative sparing of the basal-ganglia circuitry. Given their declarative memory deficits, AD patients were expected to exhibit greater difficulty inflecting irregular verbs and L2 regular verbs, as the past tense of these verbs is posited to be retrieved from declarative memory. The performance of the AD group was expected to not differ from that of its control group for L1 regular verbs, as these are posited to be inflected productively. The results provide partial support for these hypotheses.

The AD group made more errors overall than healthy age-matched controls, and more specifically, they left more stems uninflected, irrespective of language and verb type. This observation is interesting because it raises the possibility that the concept of verb tense may be affected by AD, leading patients to fail to mark tense more frequently than healthy adults. With regards to verb type, AD patients were more likely than their controls to substitute L1 irregular verbs with another verb. The AD patients and their healthy counterparts showed equal accuracy for regular and irregular verbs in L1, but greater accuracy for regular verbs than for irregular verbs in L2. This finding likely reflects greater knowledge of the past tense of irregular verbs in one's native language relative to a second language, due to extended practice and education within that language.

With respect to past tense generation latency, there was a tendency toward AD patients being slower overall. Within L1 only, AD patients inflected regular verbs faster than irregular verbs. This finding is interesting because it is precisely the regular verbs in L1-condition that is posited to rely on procedural memory. It is interesting therefore that the AD patients, who have impaired declarative memory but spared procedural memory, would show an advantage for the inflection of L1 regular verbs. Results from PD patients and their controls are discussed separately, but it is noteworthy that they do not show faster inflection of regular than irregular verbs in L1.

Regarding the effect of past tense frequency, the AD group did not differ from their healthy counterparts in latency to generate the past tense of low-frequency verbs but differed from them in latency to generate the past tense of high-frequency verbs, irrespective of verb type. This is consistent with impaired declarative memory, as follows: When a past tense is infrequent, AD patients and their controls take an equal amount of time to generate it. When a past tense is frequent, healthy older adults benefit from this and their inflection latency is reduced. By contrast, since their declarative memory is dysfunctional, AD patients fail to benefit from the increase in frequency. Based on the position that the past tense of regular verbs in L1 are inflected procedurally, frequency effects were expected to differ based on verb type and language, but these two factors did not significantly interact with verb past tense frequency and thus did not moderate the effect of verb past tense frequency on latency to generate the past tense. As anticipated the AD patients did not display frequency effects, defined as a significant negative correlation between latency and past tense frequency. This finding was expected, since frequency effects reflect successful retrieval from declarative memory, and the AD patients were shown to have impaired declarative memory.

In sum, selective declarative memory deficits were documented in the AD group. AD patients made more errors overall and left more stems uninflected. The AD group and its control group displayed better accuracy in L1, likely a reflection of greater exposure. AD patients inflected L1 regulars fastest, which is a process posited to rely most on procedural memory. Finally, AD patients did not display frequency effects, defined as a negative correlation between inflection latency and past tense frequency, and whereas their healthy counterparts benefited from an increase in frequency to generate the past tense of irregular verbs faster, the AD patients did not. These findings provide mitigated support for the position that the past tense of irregular verbs and L2 regulars is dependent upon declarative memory, and that of L1 regulars is dependent upon procedural memory. On one hand, AD patients had declarative memory impairments and failed to show the frequency effects for irregular verbs that healthy adults show, which does highlight a link between declarative memory and the past tense generation of irregular verbs. In addition, the AD patients displayed faster inflection of L1 regulars, posited to depend on the specific memory system spared in AD. On the other hand, the strength of the evidence is weakened by the fact that AD patients did not make more errors than their healthy counterparts in inflecting irregular verbs and L2 regular verbs. It may be that the working memory demands of the task resulted in a greater error rate across any verb type and language. This effect may have concealed that of the declarative memory deficit. Stimuli were presented in the auditory modality to render the task as naturalistic as possible. However, this resulted in the verb stem not remaining available and having to be kept in working memory to allow the participant to respond with its past tense form. The failure to replicate the findings of Ullman et al. (1997) who demonstrated a greater error rate for irregulars than for regulars, in L1 for AD patients, may be due to the fact that their sentences were presented visually and thus their processing may not have required as much working memory capacity as did the sentences in the current study. In addition, the sentences of Ullman et al. (1997) did not vary much with regards to semantics, as the format "Every day, I ___. Just like every day, yesterday I___." was employed on each trial. In this study, meaningful information was presented between the verb stem and the final word of the sentence (e.g., "Sometimes, I scan *through novels. At the bookstore* yesterday, I _____ through novels"). In French, which constituted L1 for most participants, the phrase between the verb stem and the final word described an action (e.g., "Tous les soirs, Anne corrige les devoirs de sa fille. *Son mari est revenu* hier pendant qu'Anne _____ les devoirs de sa fille.", which can be translated as "Every evening, Anne corrects her daughter's homework. *Her husband came back* yesterday, while Anne was _____ her daughter's homework."). This was necessary in order to make the imperfect tense the only correct tense that could be generated. However, in a population with limited memory capacity, the complexity of the sentence structure combined with the auditory mode of presentation, could have contributed to the AD group making more errors overall and failing to display a precise pattern of error based on verb type and language.

<u>Memory and Language in PD</u>

The memory performance of the PD group was very similar to that of the healthy older participants. As predicted, PD patients performed as well as their healthy counterparts on the word list learning and design recognition tests of declarative memory, the BEM and RAVLT respectively. However, contrary to expectations, the PD group did not provide irrefutable evidence of procedural memory deficits. In the non-verbal domain, we failed to replicate Westwater et al. (1998), as both the PD group and their healthy counterpart displayed procedural learning, as evidenced by a significantly longer location naming latency on Block 5, in which the asterisk appeared randomly at one of four locations at the bottom of the computer monitor, than on Block 4, in which the asterisk appeared in the same sequence for the 40^{th} to 50^{th} time. The effect of fatigue may have contributed to the difference in naming latency between Blocks 5 and 4. The SRT took approximately 20 min to complete, during which the participant looked at the computer monitor and tracked the asterisk. This test was always the last memory test to be administered, and several participants expressed that they felt fatigued. Since the randomized block (Block 5) was presented last, fatigue may have had its greatest effect on the naming latencies for that block, increasing the difference in lantency between Block 4 and Block 5. In addition, it is likely that PD patients experienced greater fatigue than healthy subjects. As a consequence, fatigue could have magnified the learning score of the PD group relative to that of the NCPD group (naming latency in Block 5 minus Block 4). In sum, it is possible that a mild deficit in sequence learning in PD patients went undetected on the SRT because of the confounding effect of fatigue. On the mirror-reading task, the PD group displayed a significant repetition priming effect, comparable to that exhibited by the normal controls. However, whereas the older controls displayed a statistically significant reduction in reading latency for new words with practice, the PD group only exhibited a statistical trend towards the same effect.

Overall, the declarative memory findings suggest healthy medial temporal lobe function, but the procedural memory results did not provide strong evidence of impairments in the basal ganglia and/or basal-ganglia related circuitry contrary to expectation. Patients in this study were mostly in the early stages of the disease: On the Hoehn & Yahr scale, most were within Stages 1 or 2, and few were within Stage 3. None were within Stages 4 and 5. It is possible that the disease had not progressed sufficiently for impairments in procedural memory to be easily detectable. To the extent that the language changes in PD are associated with impairments in the procedural memory system, failure to demonstrate clear deficits in procedural memory weakens the conclusions that can be drawn from language tests results.

Before the performance of the PD group on the PTG is discussed, a further challenge that is specific to testing the hypotheses made for this group must be described.. If a participant cannot retrieve the past tense of an irregular verb from declarative memory, he/she can hardly compensate by implementing a procedure. Failure to retrieve the past tense of an irregular verb from declarative memory will result in an incorrect output. By contrast, if a participant cannot implement a procedure on-line to inflect a regular verb, he/she can compensate by either retrieving the form from declarative memory (whether it is stored as "walked" or "walk+ed", for instance) or retrieve the rule explicitly (+ed) and apply it to the input in a controlled manner. The use of either compensatory strategy would result in a correct inflection being produced. A defect in L1 grammar for regular verbs may therefore be difficult to detect on the PTG.

The overall accuracy of the PD group in generating the past tense of regular verbs and pseudo-verbs, in L1 and L2, was almost identical to that of the NCPD group.

However, PD patients made more errors than their controls in generating the past tense of irregular verbs, regardless of language. As hypothesized, and consistent with Zanini et al. (2004), PD had an impact on L1 but not L2. Within L2, both the NCPD and PD participants made more errors for irregular verbs than for regular verbs, a finding observed in each of the other groups and interpreted as reflecting greater exposure to L1 than to L2. However, within L1, whereas healthy controls made a comparable number of errors for each verb type, PD patients made more errors for irregular verbs than for regular verbs or pseudo-verbs.

With regards to inflection latency, there was a trend for the NCPD and PD groups combined, to take longer to inflect L2 verbs and irregular verbs, a finding similar to that observed to in young and older healthy controls. One interesting finding emerged: Whereas the NCPD group inflected regular verbs significantly faster than they inflected irregular verbs, irrespective of language, the PD group did not. This finding would support the hypothesis that the patients have greater difficulty inflecting regular verbs relative to irregular ones. Past tense frequency did not have a significant effect on past tense generation latency for PD patients. This finding is similar to that in the AD group and likely reflects disruption in one or more of the normal processes involved in past tense generation.

General discussion: Young adults made more errors and were slower generating the past tense of L2 irregular verbs relative to other verbs, perhaps because these were not learned as well as L1 irregular verbs or could be more susceptible to forgetting. Within the young sample, frequency effects were observed for irregular verbs. Within L2 but not L1, high-frequency past tenses were retrieved faster than low-frequency ones, suggesting that declarative memory plays a larger role in sustaining L2 relative to L1. Overall, the performance of the young adults is generally consistent with irregular verbs and L2 regular verbs being sustained by declarative memory and L1 regular verbs by procedural memory. The limitation of the evidence is that frequency effects were not observed for L2 regulars specifically. As predicted, aging negatively affected episodic memory, but did not affect procedural memory or past tense generation accuracy or latency. To our knowledge, the effect of aging on past tense generation has not been studied, and it would be interesting to see these findings replicated.

As predicted, AD negatively affected declarative memory , but not procedural memory. AD patients left more stems uninflected relative to healthy controls, suggesting that the disease may affect tense marking. The results did not directly replicate Ullman et al. (1997) who reported a higher error rate for irregular verbs relative to regular and pseudo-verbs in L1. However, the fact that AD patients took longer to inflect irregular verbs than regular and pseudo-verbs in L1, whereas their controls did not, is compatible with the position that AD affected the retrieval of irregular past tenses more than the generation of the past tense of regular verb. Said differently, in L1, the accuracy data did not replicate Ullman et al. (1997), but the latency data provided indirect evidence that converges with Ullman et al. in that AD patients were slower, and thus perhaps had more difficulty, inflecting irregular verbs than regular verbs. In addition, patients took longer to inflect regular verbs in L2 than in L1. This would suggest that generating the past tense of regular verbs in L2 places more demands on declarative memory than generating the past tense of regular verbs in L1, and is compatible with the position that AD affects an L2 more than an L1. This is consistent with Paradis' and Ullman's neurolinguistic model of L1 and L2, and with evidence that AD affects an L2 more than an L1 (De Vreese et al., 1988; Dronkers et al., 1986; Friedland & Miller, 1999; Hyltenstam & Stroud, 1989, 1993; De Picciotto & Friedland, 2001; De Santi et al., 1989; Meguro et al., 2003).

As predicted, PD did not affect declarative memory. However, we did not obtain strong evidence of procedural memory impairments, contrary to expectations. Failure to document clear deficits in procedural memory in PD could be due to the specific measure used which may, for instance, be vulnerable to the effect of fatigue. The PTG performance of the PD group provides partial support for the position that only L1 regular verbs are inflected productively. The PD group differed from its control group only within L1, consistent with evidence that PD impacts L1 more than L2 (Zanini et al., 2004). When examined closely, the evidence from the PD group supporting the position that irregular and L2 regular verb inflection is dependent upon declarative memory and L1 regular verb inflection on procedural memory, is ambiguous. With regards to the accuracy data, it is irregular verbs in L1 that were negatively impacted and not regular verbs, contrary to predictions from Ullman's neurolinguistic model of L1 and L2. However, the fact that whereas healthy adults generated the past tense of regular verbs faster than that of irregular verbs, PD patients did not, would indicate that PD affects negatively affects the inflection of regular verbs, as predicted by Ullman's neurolinguistic model of L1 and L2 .

Implications: Together, the findings from verb inflection support the position that an L2 learned after puberty places more demands on declarative memory than does an L1, in accordance with Paradis'work (1994, 1997, 1998a, 1998b, 2004). As Paradis predicted, AD patients tend to show greater impairments in L2, and PD patients differ from their controls in L1. However, support for the position that regular verbs in L1 are inflected procedurally, whereas the past tense of irregular verbs and L2 regular verbs is retrieved from declarative memory is weak. In the context of patient care, results from this study provide converging evidence that AD patients may do better in an L1 environment than in an L2 setting. Results from the PD cohort are perhaps more preliminary.

Limitations: This research was challenging on several fronts. First, there are challenges associated with participants. Individual differences in bilingualism can be enormous. Variables such as age and context of acquisition, formal language or instruction, proficiency and context of use, and many more can all affect bilingual performance. Patient groups are notoriously heterogeneous. In addition the recruitment of patients meeting highly specific inclusion and exclusion criteria was the largest challenge to this research, which limited the sample size.

A second limitation relates to the neurolinguistic model of bilingualism. The hypotheses derived from Paradis' and Ullman's neurolinguistic model of L1 and L2, are based on links between neurofunctionally separable memory systems and specific language functions. The fact that two circuits are neurofunctionally separable does not mean that they do not interact. During the generation of the past tense, regardless of verb type, and irrespective of language, both circuits are likely involved, one to a greater extent than another. It may be that accuracy and latency measures do not have the necessary resolution to capture the relative contribution of each system very well, leading to some of the mitigated findings described. Aside from the fact that the two systems could be recruited and work in parallel, there is potential overlap in the processes used to generate the past tense of verbs. The past tense of an regular verb, for instance, could be produced by implementing the "+ed" procedure, by applying the "+ed" rule declaratively, or by retrieving the past tense directly from declarative memory (e.g., "walked"). Moreover, it does not have to be that all the time the past tense of all regular verbs is produced in one specific way only. There could be variability such that when certain factors are present the past tense is retrieved from declarative memory, and that under a different set of circumstances it is produced generatively. In addition, and as pointed out by proponents of connectionist models of verb inflection (e.g., Joanisse & Seidenberg, 1999), irregular verbs are not entirely irregular, and patterns can be observed (e.g., "sing-sang", "ring-rang", etc), and the past tense of some regular verbs can be pronounced slightly differently from what would be a perfectly regular pronunciation.

Third, we must consider the methodology. One challenge relates to translation equivalents of tests. We assume that the French and English versions were matched on all important variables and were therefore equivalent, but both the stimuli and task may differ across language in ways that could affect performance. For instance, the imperfect was selected to avoid limitations of the "passé composé" (please see the method section). However, the imperfect is a tense usually acquired somewhat later and is in some respects associated with school. Most Quebecers often use the phrase "en train de" instead of the imperfect (e.g., "Elle m'a appelé hier pendant que...j'étais en train de *faire* la vaisselle" instead of "...pendant que je *faisait* la vaisselle"). One AD patient commented that generating the imperfect reminded her of when she was in school and the nuns were teaching that tense. An additional caveat is that the sentences were presented over speakers and the participant was asked to listen and generate the verb. It was thought that spoken sentences would elicit implicit linguistic competence and minimize the likelihood that participants would treat the sentences and the verbs in a declarative manner. The disadvantage of this method was that the participants had time to retrieve from memory or to productively generate the past tense of the stems, while the sentences were being played. To discourage participants from doing so, the sentences were built such that the correct inflection could not be produced until the very last few words. In English, the participants could not answer correctly before hearing "yesterday I ___", for the experimental sentences, or "tomorrow I will be ___", for the foils, and in French, they could not respond before hearing "pendant que [name] ____", for the experimental sentences, or "pendant que nous ____", for the foils. This manipulation was ideal in English, as the participant could not prepare the stem part of the response in advance (e.g., TAUGHT or TEACHing). In French however, the stem change required to generate the past tense of irregular verbs is the same for the third person singular as for the first person plural (e.g., "bois-buvait" or "bois-buvions"). Thus, if a participant had been keen on answering correctly, generating the stem change early on could have been a strategy (e.g., BUVais or BUVions). This methodological factor is something important to consider because 80% of the participants were native French speakers. Had we been able, within each group, to obtain a sample with half the participants having French as an L1 and half having English as an L1, these methodological issues could have been examined more directly.

Future directions: This is the first study of verb inflection to compare the L1 and L2 of bilingual participants. To be useful, the findings will need to be replicated. Replication could involve the same stimuli, task, and population, or involve a different methodology.

Verb inflection is only one of many paradigms within which lexical and grammatical functions can be examined, and future research could examine the formation of the plural in bilinguals populations, for instance. Cross-linguistic studies are important in ruling-out language-specific effects, and testing the same set of hypothesis in bilinguals with languages other than French and English would be informative. Finally, as previously mentioned, when differences are observed on accuracy or latency measures, it is difficult to ascertain whether these are qualitative or quantitative, and to specify their exact nature. Measures with exquisite time resolution, such as event-related brain potentials, or spatial resolution, such as brain imaging measures, could further our knowledge of how memory and language interact in bilingual healthy and in bilingual patient populations.

General Discussion

As stated by Fabbro (1999), most people speak more than one language. As life expectancy continues to increase, the prevalence of age-related diseases rises. Understanding how healthy aging and age-related diseases affect language in bilinguals is important not only because of its implications for our understanding of brain-language relations, but also because of its potential to help design interventions to provide better care for patients. The goal of this thesis was to investigate memory and language in young and older healthy bilinguals, and in bilingual AD and PD patients, to further our understanding of age-related changes in language, and language deterioration in age-related diseases, as well as our understanding of brain-language relations. The neurolinguistic models of Paradis (1994) and Ullman (2001) were employed, which posit that for an L2 learned late, the lexicon and L2 grammar depend on the declarative memory system, whereas L1 grammar depends on the procedural memory system. As AD chiefly impairs declarative memory, and PD predominantly procedural memory (Gabrieli, 1998), the models predict a double dissociation with AD patients displaying greater impairments on measures of the lexicon and L2 grammar, and PD patients showing greater difficulty on measures of L1 grammar. Study One (Manuscript One) tested these hypotheses by comparing the L1 and L2 performance of bilingual AD and PD patients, relative to that of healthy controls, on a picture description task, and Study Two (Manuscript Two) on a past tense generation task. The contribution of aging was inferred from the L1 and L2 performance of the healthy older controls relative to that of a group of healthy young bilinguals. Participants also completed declarative and procedural memory tests, to permit closer examination of the link between memory and language.

The discussion is structured as follows: First, the memory and language results are reviewed. The implications of the findings are then discussed in the context of the declarative-procedural model of the lexicon and grammar, and of our understanding of the relationship between memory, language, and the brain. Implications are then discussed in relation to the understanding of aging in bilinguals, and language deterioration in AD and PD. Additional implications for the understanding of language and brain relations are addressed. A summary, future directions, and conclusions, are then presented.

Memory Findings

Memory tests were administered to evaluate whether declarative memory deficits predominate in AD and procedural memory deficits predominate in PD. The RAVLT (Lezak, 1983) and BEM (Signoret, 1991) were chosen to test declarative memory in the verbal and visual modalities, respectively. The RAVLT has been shown to be sensitive to AD (see Spreen & Strauss, 1991), and the BEM was selected as a test of visual memory because it does not require drawing, which would have been difficult for PD patients and could have involved procedural memory. As expected, AD patients were clearly impaired on these tests, whereas PD patients were not. As expected also, given that aging affects episodic memory (Flicker et al., 1986), older adults remembered fewer words and designs on the RAVLT and BEM, respectively. The mirror-reading task and SRT were selected to test procedural memory in the verbal and visual modality, respectively. These tasks were chosen because they have been shown to be sensitive to PD (Westwater et al., 1998 for the SRT; Koenig et al., 1999 for the mirror-reading task), but not to AD (Knopman & Nissen, 1987 for the SRT; Deweer et al., 1993 for the mirror-reading task). As predicted, AD patients displayed procedural learning on the mirror-reading task and SRT. However, contrary to expectations, PD patients did not show significantly reduced procedural learning. On the SRT, learning was inferred from the difference between the average RT in the last learning session, expected to be short, and the average RT in the random condition, expected to be long. However, the random condition occurred at the end of the test, and fatigue may have inflated the RT for that condition, more so for the PD group who seemed more vulnerable to fatigue, thereby magnifying the measure of procedural learning for the PD group. Alternatively, it may be that PD patients did not have impaired procedural memory. After all, they were in the relatively early stages of the disease, i.e., mostly within stages 1 and 2 on the Hoehn and Yahr scale. However, deficits in procedural memory have been observed in patients in the same relatively early stages of the disease (e.g., Daum et al., 1995). Consistent with procedural memory being relatively immune to aging (Smith & Fullerton, 1981), the performance of the older and younger groups did not differ on the mirror-reading task and the SRT.

Summary: On the declarative memory tests, the young group performed better than the older group, who in turn performed better than the AD group, and on the procedural memory tests, older adults and AD patients benefited from repetition as much as their controls did, as expected. The PD group displayed intact declarative memory, as predicted, but was not impaired on the procedural memory tests administered.

Findings from Picture Description

The picture description task was chosen because it is relatively naturalistic and minimizes working memory demands. This is advantageous because working memory has been shown to be reduced in aging, and in AD and PD (e.g., Altmann, 1999; Bublak et al., 2002; Hasher and Zacks, 1988). The speech of older adults is characterized by a simplification of grammar (see the work of Kemper) and occasional word-finding difficulties (e.g., Au et al., 1995). The picture description performance of AD patients is marked by lexical difficulties and relatively intact grammar (Almor et al.,1999; Bucks et al., 2000; Cummings et al., 1988; Hier et al., 1985; Illes, 1989; Nicholas et al., 1985). One study examined picture description in PD and documented grammatical difficulties in the context of intact lexical ability (Murray, 2000). Picture description had never been examined in L2 in aging, or in AD or PD. Lexical measures included the percent of unique words, the percent of unique nouns, the percent of pronouns relative to nouns, the percent of lexical errors, and the percent of open-class words. Grammatical measures included the average number of words per utterance, the percent of subordinate clauses, the percent of correct utterances, and the percent of grammatical errors. The amount of information conveyed was measured, and verbosity inferred from the total number of utterances and of words. Based on the declarative-procedural model of the lexicon and grammar, and on AD affecting declarative memory and PD procedural memory, AD patients were expected to be impaired mostly on the grammatical measures in L2 and on the lexical measures, whereas PD patients were expected to be impaired chiefly on the grammatical measures in L1.

Aging: The performance of the older adults did not differ substantially from that of the younger cohort, except that older adults, and not younger ones, tended to talk more and produced more correct utterances in L1 than in L2. This suggest that the older adults were L1-dominant at the level of the grammar (i.e., may not have reached equal proficiency in L1 and L2), and/or that aging impacts L2 more than L1.

AD: The performance of the AD group differed from that of its control group on lexical measures in L1, with AD patients having made more lexical errors, used more pronouns relative to nouns, and used fewer closed-class words. AD patients displayed evidence of grammatical limitations on the percent of correct utterances in L1, but this is a measure sensitive to both lexical and grammatical errors. Thus, in L1, the findings replicate the AD literature by documenting greater lexical than grammatical impairments (Almor et al.,1999; Bucks et al., 2000; Cummings et al., 1988; Hier et al., 1985; Illes, 1989; Nicholas et al., 1985). Based on the declarative-procedural model of the lexicon and grammar, greater impairments were expected in L2 than in L1. However, no impairments were observed on any of the lexical or grammatical measures within L2, suggesting conversely that AD impacts L1 more than L2. As will be discussed later, the literature on bilingual AD is too narrow to allow for clear predictions regarding L2 performance. Finally, AD speech was less informative than the speech of healthy older adults, equally so in L1 and L2. This finding is consistent with the literature in L1, and may suggest a conceptual basis to the poverty of content of AD speech (Almor et al., 1999; Bschor et al., 2001; Bucks et al., 2000; Croisile et al., 1996; Cummings et al., 1988; Ehrlich et al., 1997; Hier et al., 1985; Illes, 1989; Nicholas et al., 1985).

PD: The performance of the PD group in L1 was consistent with the literature, with PD patients having produced more grammatical errors and fewer correct utterances than their controls, in the context of unimpaired lexical performance (Lewis et al., 1998). Results in L2 are equivocal, with PD patients having made more grammatical and lexical errors than their controls. PD patients also tended to speak more, but use fewer unique words, in L1 relative to L2.

Summary: The picture description results would suggest that if aging has an effect on language production, the effect is more pronounced in L2 than it is in L1. They indicate by contrast that AD affects the lexicon more than grammar, as predicted and consistent with the literature, but that this effect is limited to L1. Finally, the picture description results indicate that PD affects grammar more than the lexicon in L1, as hypothesized and consistent with the literature, but that it also affects grammatical and lexical processing in L2.

Findings from Past Tense Generation

The past tense generation task (PTG) was selected because it allows for lexical and grammatical abilities to be tested similarly. In picture description, lexical measures are single word measures, whereas grammatical measures are sentence level measures. By contrast, the PTG yields lexical (i.e., production of the past tense of irregular verbs) and grammatical measures (i.e., generation of the past tense of regular verbs) matched on complexity (i.e., one word), syntax (i.e., tensed), and meaning (i.e., past). One study examined past tense generation in AD and PD in L1 (Ullman et al., 1997), but none in L2 or in aging. For the PTG, participants generated the past tense of verbs embedded in meaningful sentences. There were two measures: accuracy and past tense generation latency. Based on the dual-system model of verb inflection, the past tense of regular verbs is produced by implementing a procedure on line, which depends on procedural memory. For instance, to produce “walked”, “ed” is affixed to “walk”. By contrast, the past tense of irregular verbs is retrieved from declarative memory (e.g., taught). As such, past tense production of irregular verbs is a lexical function, and past tense generation of regular verbs a grammatical function. Given that AD is associated with declarative memory deficits, and PD with procedural memory impairments, AD patients were expected to be impaired in generating the past tense of irregular verbs and PD patients in producing the past tense of regular verbs, in L1, as demonstrated by Ullman et al. (1997). Since the declarative-procedural model of the lexicon and grammar posits that L2 grammar and lexicon are dependent upon declarative memory, AD patients, and not PD patients, were expected to be impaired for irregular and regular verbs in L2. Finally, the effect of verb past tense frequency on the latency to respond was examined. The rationale is that if the past tense of a verb is retrieved from declarative memory, as posited for irregular verbs and L2 regular verbs, then an effect of past tense frequency on latency should be seen. If the past tense of a verb is generated productively, as is posited for L1 regular verbs, then frequency effects should not be seen because implementing the "+ ed" procedure proceeds regardless of verb characteristics, including frequency (see Pinker, 1999). Two major ways to test the effect of verb frequency on verb inflection are to compare the mean latency to generate high-frequency past tenses to the mean latency to generate low-frequency past tenses, and to test the statistical significance of the correlation between past tense frequency and latency to generate the past tense.

Aging: The responses of older adults were as accurate and as fast as those of younger adults. Frequency effects were observed in L2 only, with faster generation of high-frequency past tenses relative to low-frequency ones, suggesting greater involvement of declarative memory in L2 than in L1. Using a correlational method, frequency effects, with past tense being retrieved faster as past tense frequency increases, were limited to the young group, for irregular verbs, in L1 and in L2, and not for regular verbs in L1. No significant frequency effect was observed for regular verbs in L2, failing to show that the past tense of regular verbs in L2 is retrieved from declarative memory.

AD: The AD group made more errors and were slower overall than their healthy counterparts. AD patients left more stems uninflected, irrespective of language and verb type, which raises the possibility that the concept of verb tense may be affected by AD, leading patients to fail to mark tense more frequently than healthy adults. AD patients inflected regular verbs faster than irregular verbs in L1 only. It is precisely the regular verbs in L1-condition that is posited to rely on procedural memory. The AD group generated the past tense of low-frequency verbs as fast as their controls did, but were slower than them in generating the past tense of high-frequency verbs. This shows that AD patients did not benefit from the increase in past tense frequency, consistent with declarative memory being dysfunctional. This is corroborated by them failing to display frequency effects, defined as a significant negative correlation between latency and past tense frequency, since these reflect successful retrieval from declarative memory.

PD: PD patients made more errors than their controls did in generating the past tense of irregular verbs. Whereas their control group inflected regular verbs faster than irregular verbs, the PD group did not, suggesting that the patients have greater difficulty inflecting regular verbs relative to irregular ones. Past tense frequency did not have a significant effect on past tense generation latency for PD patients, likely reflecting disruption in one or more of the normal processes involved in past tense generation. In sum, the PD findings are equivocal. Patients made more errors for irregular verbs, suggesting lexical difficulty, but they also did not show the latency advantage that their controls did for regular verbs, suggesting grammatical impairments.

Summary: The findings suggest that aging has little effect on past tense generation. AD patients made more errors and were slower than their controls. They left more stems uninflected, suggesting a degradation of verb tense concept. AD patients inflected regular verbs faster than irregular verbs, in L1 only, reflecting better grammatical than lexical processing. Finally, AD group and its control group generated the past tense of low-frequency verbs equally slowly, but the control group generated that of high-frequency verbs faster than the AD group, which may again reflect lexical deficits in the AD group. PD patients made more errors for irregular verbs, suggesting lexical difficulty, but they also did not show the latency advantage that their controls did for regular verbs, suggesting grammatical impairments.

Results from the PTG do not replicate Ullman et al. (1997). Differences in methodology, most inherent to language (English versus French), may account for the divergences in results. First, the imperfect was selected to avoid limitations of the "passé composé", discussed in the method section of the PTG manuscript. However, the imperfect is a tense acquired later and in some respect associated with school. Quebecers often use the phrase "en train de" instead of the imperfect (e.g., "Elle m'a appelé hier pendant que...j'étais en train de *faire* la vaisselle" instead of "...pendant que je *faisait* la vaisselle"). Second, formation of the past tense for French irregular verbs requires declarative memory (i.e., to know the stem change, e.g., "b<u>ois</u>-b<u>uv</u>ait"), but also procedural memory to add the [ɛ] to mark the passé composé ("buv<u>ait</u>"). Recently, Terzi, Papapetropoulos, and Kouvelas (2005) examined past tense generation in Greek in PD patients. Greek is like French in that for irregular verbs the stem changes in past tense production, making irregular verbs irregular, but a past tense marker is also affixed, in addition to the stem change, to mark the past tense. Their results also did not replicate Ullman et al. (1997) as PD patients made more errors than their controls equally so for irregular and regular verbs. Thirdly, whereas Ullman et al. (1997) had participants read sentences that followed a fixed format ("Every day I ___. Just like every day, yesterday I ___"), we had participants listen to sentences with various meanings, to minimize the likelihood that participants would treat the stimuli in a declarative manner, and to make the task more naturalistic. The drawback of this method is increasing working memory load, as the stimuli did not remain available to the participants. Finally, a challenge to the interpretation of the PTG results was the high rate of regularization errors (e.g., "swimmed") in L2 in each participant group, which may have obscured effects of verb type or language, and may indicate the participants were not as proficient in L2 as in L1.

Picture Description and PTG Findings

Together, the findings suggest that aging has little effect on elicited speech and verb inflection, although it may be associated with mild changes in L2 grammar. The speech and verb inflection performance of AD patients converge to indicate that AD affects lexical processing more than grammatical processing in L1. The L2 performance of AD patients did not reveal such a distinction between the lexicon and grammar, as predicted by the declarative-procedural model of the lexicon and grammar, but the speech data would suggest that L2 was better preserved than L1. AD may affect conceptual-semantic processing such that speech is less informative and patients fail to mark verb tense more frequently, relative to healthy older adults, in each language. The speech and verb inflection performance of PD patients together suggest perhaps greater grammatical than lexical impairment in L1, but both grammatical and lexical difficulties in L2.

Implications for Memory, Language, and the Brain

How the brain sustains linguistic functions remains to be fully deciphered. Case reports in the aphasia and bilingual aphasia literature illustrate a wide range of phenomena to be explained, such as better recovery of a language a patient did not speak very well or often before injury, relative to the mother tongue (see Paradis, 1983 for a historical review of case studies). The process of language deterioration in AD and PD, in monolinguals and bilinguals, remains to be elucidated. The declarative-procedural model of the lexicon and grammar is appealing because of its potential to explain and predict how brain insult or degeneration will affect language in bilinguals and polyglots. It has received support from neuroimaging and ERPs studies, as well as from patient data, especially within native-speakers of a language, but also in bilinguals. The declarative-procedural model of the lexicon and grammar predicts that AD will affect mostly the lexicon and L2 grammar, and that PD will affect predominantly L1 grammar. The current results only partially support these hypotheses. AD patients showed greater lexical than grammatical impairments in L1, as predicted, but no grammatical nor lexical impairment in L2. PD patients displayed greater grammatical than lexical deficits in L1, at least in describing pictures, but also evidenced grammatical difficulties in L2. The L2 data are not consistent with the declarative-procedural model of the lexicon and grammar. There are limitations to the testability of the model, mostly related to overlap in the neural substrates of declarative and procedural memory, to interactions between the lexicon and grammar, and to the issue of proficiency. These are discussed next, followed by a description of the language characteristics of the participants, which may have contributed to the results.

Limitations to the Testability of the Model: The declarative-procedural model of the lexicon and grammar is based on the distinction between declarative memory and procedural memory, and between the lexicon and grammar, together with the similarity between the processes of declarative memory and the lexicon, and between those of procedural memory and grammar. The validity of the model depends to a large extent on whether the two memory systems are neurofunctionally separable, and whether the two language functions are neurofunctionally distinct. The amnesia and aphasia literature demonstrate these neurofunctional separations, respectively (see Paradis, 2004 for a review). Patient data demonstrate that declarative memory and procedural memory are dissociable, and that the lexicon and grammar are also dissociable. However, it provides little information on how the declarative and procedural memory systems interact, and how lexical and grammatical functions interact. Yet, there is overlap in the neural substrates of declarative and procedural memory, and in the processes of the lexicon and grammar. This overlap may well influence how neurodegenerative diseases, like AD and PD, will manifest, with regards to memory and language, and is reviewed next.

Overlap between Declarative and Procedural Memory: The declarative memory system depends mostly on medial temporal lobe structures, including the hippocampal region and parahippocampal cortex. The hippocampus projects to midline diencephalic nuclei, especially the mammillary bodies and portions of the thalamus. Prefrontal regions have been implicated in the declarative memory system (Buckner & Wheeler, 2001). Ventro-lateral prefrontal cortex plays a role in the encoding of new memories and the selection and retrieval of declarative knowledge (Buckner & Wheeler, 2001). The posterior/dorsal inferior cortex and the anterior/ventral inferior frontal cortex are involved in phonology and semantics, respectively (Fiez, 1997; Poldrack, Wagner et al., 1999). Anterior frontal-polar cortex and portions of the cerebellum are implicated in the retrieval of memories (Buckner & Wheeler, 2001; Desmond & Fiez, 1998; Ivry & Fiez, 2000). In sum, several frontal lobe structures are part of the declarative memory system. The procedural memory system depends mostly on frontal/basal ganglia circuits. The basal ganglia receive input projections from many cortical areas, especially in frontal cortex, but also from medial temporal lobe structures (Alexander & Crutcher, 1990; Middleton & Strick, 2000; Wise et al., 1996). This shows that regions associated with declarative memory also part of the procedural memory system. In summary, there appears to be significant overlap in the neuroanatomy and neurophysiology of the declarative and the procedural memory systems (for more information, please refer to Ullman, 2004). It is possible that this overlap could partly explain why some studies have found AD patients to be grammatically impaired, a finding ascribed to working memory deficits (Grossman & White-Devine, 1998; Small et al., 2000; Waters et al., 1995; Waters et al., 1998). The overlap between the neural substrates of declarative and procedural memory may also partly account for the finding of impairments in PD patients on tests of fluency and naming (Bayles, 1984; Bayles & Boone, 1982; Bayles & Tomoeda, 1983), although it should be noted that these tasks usually involve a speed component and PD patients display reduced processing speed relative to healthy older adults (Grossman et al., 2002).

Interaction between the Lexicon and Grammar: It is obvious that lexical and grammatical functions interact in speech. Several models of speech production have emerged. De Bot (1992, 1996) proposed a model of bilingual speech production based on Levelt's model of speech production. De Bot's model is briefly described here to illustrate how the lexicon and grammar may interact in language production, and findings from this study are discussed in relation to it. The model includes three subsystems: a conceptualizer, a formulator, and an articulator. The conceptualizer contains the information to be expressed in language but is not linguistic in itself. This subsystem has access to information stored in declarative memory, and likely represented in the anterior portions of the frontal lobe of both hemispheres and the parieto-temporal areas of the left hemisphere. Bilinguals may have a formulator and a separate lexicon for each language, or a unique large system that stores all data concerning the two languages (Fabbro, 1999). The formulator converts the pre-verbal message into a speech plan by selecting the lexical units and applying grammatical rules. The articulator puts the speech plan into action. Green (1986) suggests that all languages of a bilingual or multilingual are activated at all levels, with the exception of the articulation subsystem. Data from this study would suggest that AD may affect the conceptualizer, as the speech of patients was less informative than that of their counterparts, regardless of language. It also affects the formulator, as the lexical units appeared poorly selected in AD speech, as reflected in the greater rate of lexical errors. The data from this study would seem to suggest that the formulator may function somewhat differently based on language, as AD affected the lexicon in L1 and not L2. Cohesion of discourse was not measured in this study, but the literature typically reports reduced cohesion for AD patients (e.g., Duong et al., 2005), which would suggest interference with the functions of the articulator or the conceptualizer. PD did not appear to affect the conceptualizer, as the speech of PD patients was as informative as that of their healthy counterparts. The disease likely affected the formulator or the articulator, based on the L1 and L2 grammatical deficits observed.

Additional Limitation to Testability, and Patient Characteristics: To meaningfully compare decline in L1 and L2, in a cross-sectional design, patients need to have been fluent in each language pre-morbidly. Otherwise a weaker L2 performance, for instance, could not be attributed to the disease. Fluency is developed through practice, and older research participants have often had 40-60 years of experience using L2. Both Paradis and Ullman posit that it is the "extent" to which grammar relies on procedural and on declarative memory that differs between L1 and L2. That extent varies inversely with conversational experience, in addition to other variables. It may be that the only difference between L1 and L2 in a proficient older bilingual is that in L1, implicit linguistic competence was acquired before metalinguistic knowledge, whereas in L2, metalinguistic knowledge was acquired before implicit linguistic competence. If this is the case, testing the declarative-procedural model of the lexicon and grammar in neurodegenerative diseases like AD and PD may require a longitudinal design. A longitudinal design can accommodate for different pre-morbid levels of L1 and L2 fluency, something which a cross-sectional design cannot do. For instance, groups of bilingual AD and PD patients could be selected that have had extensive formal education in L2, but limited conversational experience. They would likely report feeling less comfortable in L2 and their performance on language tasks, such as picture description, would be poorer in that language. However, their performance could be tracked over time to determine whether AD affect L2 more than L1 and PD affects L1 more than L2.

In sum, the declarative-procedural model of the lexicon and grammar has received a fair amount of support in L1 from healthy populations and patient populations, evidencing a distinction between the lexicon and grammar. L1 data from this study is consistent with the model. Case reports and studies from bilingual aphasics seem generally in accordance with the model. Results from studies of bilingual AD and PD patients appear consistent with the model, in that AD patients tend to switch into L1 more than into L2 (Hyltenstam & Stroud, 1989, 1993), and PD patients in one study display greater syntactic comprehension deficits in L1 than in L2 (Zanini et al., 2004), although description of the language characteristics of the patients and the brain lesions lack in detail. Testing the predictions of the model for L2 is more challenging than it is in L1, partly because of the great variability in the characteristics of the participants regarding language, as described next.

Participant Characteristics: In bilingual research, detailed description of the participants is important because there is no universal definition of a bilingual, and related to this, groups of bilinguals are notoriously heterogeneous. Several participant variables have been identified that can affect L2 processing. Among those are proficiency and language use, and age, manner, and context of L2 acquisition. In addition, individual differences can be found across linguistic domains (e.g., phonology, morphology, syntax, lexicon, semantics, etc), across domains of knowledge (e.g., an individual having completed his/her university education in L2 may not be as fluent in L1 in academia-related communication), and across modality (e.g., reading versus writing). Differences in the characteristics of populations of bilinguals are both a blessing and a challenge. They are a blessing in that the differences can yield unique information (e.g., the contrasting of high versus low proficiency bilinguals) but are a challenge to clarity and replication in the bilingual literature when not adequately described in a given study. The languages of each participant, their level of L2 proficiency and context of acquisition of L2, are reviewed below, together with patient characteristics, as these may have contributed to the results obtained. It may be noted that the recruitment of bilingual AD and PD patients meeting specific linguistic criteria is extremely arduous, as also noted by Meguro et al. (2004), which limits the sample size attainable. Together, the variability in L2 characteristics (e.g., age of acquisition, use, level of proficiency), inherent to the study of bilingualism, and small sample size, which was larger than that of any previous study, reduced the statistical power to test the hypotheses based on the work of Paradis (1994, 2004) and Ullman (2001, 2004). Patient characteristics that may have contributed to the results are described next.

L1 and L2: All participants were French-English or English-French bilinguals. Whereas we had attempted to recruit such that half the participants in each group had English as their L1, 82% of participants had French as their L1 (13/16 of young adults, 13/16 of older adults, 7/8 of AD patients and 7/9 of PD patients). Given this, language-specific effects may have contributed to the data. Potential confounds related to language differences were discussed for the PTG. However, the AD and PD groups each had its own control group. The AD control group and AD group had the same number of French-L1 and English-L1 participants. Therefore, language-specific effects may be reflected in a main effect of language (L1/L2), but language-specific effects cannot account for group differences. However, whereas six PD patients were French-L1, eight controls (NCPD) were French-L1. It is therefore improbable but possible that language-specific effects contributed to the group differences for the NCPD-PD comparisons. Finally, researchers are increasingly aware that an L2 may affect the processing of an L1, and additional languages may therefore affect processing of L1 and L2. To the extent to which this occurs, this was not a confounding factor in this study, as with a few exceptions, the participants were not fluent in a third language.

L2 Proficiency and Use: To be included in the study, participants had to report feeling equally or almost equally comfortable in English and French, and using L2 at least 30% of the time on a daily or weekly basis. On average, each group reported using L2 about 50% of the time. A limitation is failure to distinguish time involved in L2 comprehension versus production. The experimenter asked each participant what percent of their time is spent in L2, including reading, watching TV, interacting with people, etc. However, in matching each patient with a healthy control, for data analysis, the general information available on each participant about language use was taken into account. For instance, if a patient had a spouse who interacted with the patient in the patient's L2, a healthy control was selected who also had a partner who interacted with him/her in the control's L2, when feasible. Nevertheless, it is possible that some of the participants who reported using L2 more than 30% of the time, mostly read or watched TV in their L2, which could reduce the accuracy of their performance on the picture description task and the PTG, which are both language production tests. There is no reason to believe that the groups would differ in their composition with regards to the amount of regular L2 conversation that the participants have, but as this variable was not controlled for, it is a potential confound.

Age and Context of L2 Acquisition: All participants learned their L2 after age 12, except for three YC and one NC participants, and three AD participants who learned their L2 at about 8 years of age. All participants learned their L2 academically, with the exception of one young control, two healthy older controls, three PD patients and two AD patients who learned their L2 mostly through conversation. However, all participants had years of practice in L2 conversation. This is unavoidable to obtain a sample of bilinguals who report equal or close to equal proficiency in L1 and L2. Similarly, the three older groups obviously had significantly more experience with their L2 than the younger group. The young and older group could have been matched on the years of L2 use (e.g., selecting older adults who acquired L2 after age 40), but then the difference in years of experience using L1 and L2 would be much larger for the older group than the younger one. In the end, the important issue is that for each group, participants began to feel fluent in L2 at about 15 years of age (13 for the young adults, 20 for the older adults, 13 for the AD group, and 20 for the PD group). This age is after the critical period for language acquisition, although there is debate around the notion of critical period (Birdsong, 2005).

Patient Characteristics: AD patients had MMSE scores ranging from 16 to 27, with an average of 23. At least four were within the minimal range (24-29), two within the mild range (17-23), and one within the moderate range (3-16). The AD sample tested in this study was more mildly demented than the sample in some studies (e.g., Bickel, Pantel, Eysenbach, & Schröder, 2000; Croisile et al., 1996; average MMSE of 18 in each case), but equivalent to that in other studies (e.g., Chapman et al., 1998; Forbes-McKay & Venneri, 2005; average MMSE of 22 each). PD patients were selected that were not demented because dementia in PD could indicate concomitant AD, or another disorder altogether. On the Hoehn and Yahr scale (Hoehn & Yahr, 1967), five, and likely six, PD patients were in Stages 1 and 2, whereas two were in Stages 3. None of the patients were in Stages 4 or 5. The PD patients in this study tended to be in the earlier stages of impairment than those in some studies (e.g., Murray, 2000), but comparably impaired to those in other studies (e.g., Arnott et a., 2005).

Implications for Aging Bilinguals

Aging is associated with changes in attention and memory (Craik & Byrd, 1982). More specifically, it has been associated with a decrease in working memory (Hasher & Zacks, 1988) and in the episodic aspects of declarative memory, such as memory for temporally dated episodes (Flicker et al., 1986). These declines in memory are accompanied by changes in language. Relative to younger adults, older adults have greater difficulty inhibiting irrelevant information, and this has a negative impact on text comprehension (Hasher & Zacks, 1988), and on discourse, with older adults producing more off-topic speech (Pushkar, Basevitz, Arbuckle, Nohara-Leclair, Lapidus, & Peled, 2000). Older adults also tend to perform less well than younger ones on naming tasks and on semantic and letter fluency tasks (Albert et al., 1988; Au et al., 1995; Bowles et al., 1987; Nicholas et al., 1985; Sliwinski & Buschke, 1999; Welch et al., 1996). Working memory limitations, in addition to a reduction in lexical memory, may contribute to reduced fluency on semantic and letter fluency tasks, as participants must keep in mind the words already produced to avoid repeating them. Finally, aging has been associated with simplification of grammar, and it would seem that older adults avoid grammatical forms that impose high memory demands (e.g., Cooper, 1990; Kemper et al., 2003; Kemper et al., 1989; Kemper et al., 1990; Kemper et al., 2001; Kemper & Rash, 1988; Kynette & Kemper, 1986; Lyons et al., 1994). In short, age-related linguistic changes likely reflect decreased working memory to a significant extent, although, diminished semantic memory may play a role especially for lexical processing. Goral (2004) drew a parallel between age-related decline in healthy aging and L2 attrition in bilingualism. When frequency of use of a language decreases, a bilingual or multilingual begins to experience word finding difficulties and to construct sentences that are more simple grammatically, just like older adults seem to do. She also mentions the strategies that can be used to compensate, such as avoidance, rephrasing, etc, to maintain fluency. The fact that in our study, the older group performed very similarly to the young group on the picture description task may reflect the use of such compensatory strategies. However, the PTG required specific verbs to be inflected, and the performance of older adults was as accurate and as fast as younger ones. In sum, we did not observe significant age-related changes in L1 performance, but older adults may have been compensating for decrements in the lexicon and/or grammar by using strategies or with their greater linguistic knowledge and experience, of 40 years on average. ERPs could help determine whether the cognitive processes which resulted in comparable performance were qualitatively and quantitatively similar across groups.

Many older adults speak more than one language, and yet the effect of aging on language in bilinguals has been researched very little. Two studies described in de Bot & Makoni (2005) examined language attrition in bilingual older adults. One found that retention of an L2 learned in school decreased over a five year period after it was learned, and then remained stable over a 30 period, before further decline (Bahrick, 1984), and the other found relatively little L2 loss over time (De Bot & Lintsen, 1986). These studies examined L2 attrition in individuals who reached various levels of proficiency in L2 and differed in L2 use. Their goal was to track L2 proficiency over time, without comparison to L1. This is different from the question of how aging affects an L1 versus an L2 in individuals who became highly proficient in L2 and have kept using L2 on a daily or weekly basis since. This question has received little attention, and has implications for how aging will affect communication. Only two studies have directly compared L1 and L2 in young and older bilinguals. Juncos-Rabadan (1994) administered the Bilingual Aphasia Test (BAT) to sixty Galician-L1 and Spanish-L2 bilinguals. They observed that each group performed better in L2 than in L1 on the tests, and that the oldest group showed reduced performance relative to the youngest group equally in L1 and L2. Juncos-Rabadan and Iglesias (1994) replicated these findings with data from 840 participants on the BAT, in 14 languages. In both studies, language abilities were sampled well, as the BAT is a standardized test that measures a wide range of linguistic abilities, but the linguistic characteristics of the participants were not described (e.g., age and context of L2 acquisition, current L2 use, etc). Our study was therefore the first to contrast L1 and L2 in older adults who have learned L2 after puberty, feel equally or almost equally comfortable in L2 as in L1, and use L2 at least 30% of the time daily or weekly. In contrast to Juncos-Rabadan (1994) and Juncos-Rabadan and Iglesias (1994), we did not find language-related decrements in L1 and L2. The older adults performed as well as the younger ones, overall. The only difference was that on the picture description task, older adults and not younger ones, tended to talk more and produced a greater percentage of correct utterances in L1 than in L2. However, this finding may or may not be reliable, as it is based on a statistical trend, and may or may not reflect the greater impact of aging on L2 because it could alternatively be that older adults were L1-dominant at the level of the grammar (i.e., may not have reached equal proficiency in L1 and L2). In short, the results underscore the need for further research into the effect of aging on language in bilinguals. They suggest that either aging affects L1 and L2 equally and/or subtly, or that it may affect L2 to a slightly greater extent.

Implications for Language Deterioration in Bilingual AD and PD

One in 20 Canadians over the age of 65 has a diagnosis of AD (Alzheimer Society of Canada website), and one in 100 Canadians over 65 suffers from PD (Parkinson Society Canada website). Speech problems are very common in AD, and are described in Obler (1999). In the early stages of the disease, naming is most likely to be impaired. In discourse, the patient may wander off from the topic, but the conversation can still proceed. Reading comprehension is adequate although not for very complex material. In the middle stages of AD, language is like that of a Wernicke's aphasic. The patient can only name very common items, speech comprehension is as poor as that of a fluent aphasic, and speech production makes little sense. In the later stages of AD, language becomes almost nonexistent. The literature on language in mild to moderate AD is extensive, and converges to document lexical impairments in the context of relatively preserved grammar, as was observed in this study (Appell et al., 1982; Huff et al., 1986; Martin & Fedio, 1983; Nicholas et al., 1996). The literature on language in PD is also large, but has for the most part focused on the motor aspects of speech, such as articulation, rate of speech, and phonology. Nevertheless, studies that have examined the lexicon and grammar in PD typically report syntactic difficulties (reviewed in

Grossman, 1999) in the context of relatively intact naming ability and letter fluency (Lewis et al., 1998), as observed in our study.

By contrast, research on language in bilingual AD and PD is scarce, despite the fact that a large proportion of the AD and PD populations speaks more than one language. Only eight studies examined speech in bilingual AD and one in bilingual PD (De Vreese et al., 1988; Dronkers et al., 1986, cited in Hyltenstam & Stroud, 1993; Friedland & Miller, 1999; Hyltenstam & Stroud, 1989, 1993; De Picciotto & Friedland, 2001; De Santi et al., 1989; Meguro et al., 2003; Zanini et al., 2004). Sample sizes vary from one to six for bilingual AD, and language characteristics such as L2 age of acquisition, proficiency and use are not well specified. De Piciotto and Friedland (2001) examined semantic fluency and found that AD patients generated fewer items in L2 than in L1, although this was not verified statistically and L1 was the language most used by the participants at the time of the study. Meguro et al. (2003) examined linguistic functions in a sample of four Japanese-Portuguese bilinguals, and found them to be more impaired for irregularly spelled words than regularly spelled words in both Japanese and Portuguese. Hyltenstam and Stroud (1989) examined language in a patient who had learned L2 at pre-school age and one who had learned L2 later, and found the patient who had learned L2 earlier to converse better in L1, and the one who had learned L2 later to perform similarly across the two languages. Dronkers et al. (1986; cited in Hyltemstam & Stroud, 1993) report on a patient whose language abilities were affected equally in L1 and L2, whereas De Santi et al. (1989) report on four patients who exhibited different linguistic difficulties in L1 and L2. De Vreese et al., (1988) report on a bilingual AD patient who translated spontaneously into L2. The remaining two studies have been concerned with code-switching. Friedland and Miller (1999) found that code-switching did not correlate with stage of dementia, in four patients. Hyltenstam and Stroud (1993) found code-switching behavior to be equivalent in L1 and L2 in a group of six patients. As can be seen from this summary of the bilingual AD literature, findings are disparate, and we do not have a clear understanding of how AD affects the lexicon and grammar in L1 and L2. The literature on bilingual PD consists of a single study. Zanini et al. (2004) examined naming and grammatical comprehension in PD and observed deficits on grammatical comprehension only, which were more substantive in L1 than in L2. Results from our study suggest that AD affects mostly the lexicon in L1, with relative preservation of the lexicon in L2 and sparing of grammar in both L1 and L2. The results suggest that PD affects the grammar as prominently in L2 as in L1, and relatively spares the lexicon.

Understanding language deterioration in bilingual AD and PD has theoretical and practical implications. Theoretically, it provides information about language and the brain. As stated by Roberts (1998), "Just as neurologists viewed brain-damaged patients as "experiments of nature", capable or revealing aspects of brain function not apparent in neurologically intact systems, we should view bilinguals as "experiments of language", which will reveal linguistic processes and knowledge that are difficult to isolate in monolingual speakers." The examination of language in bilingual AD and PD can yield unique information because each disease affects a different neural substrate and memory system, which we believe may be involved to a different extent in sustaining L1 and L2. In practice, understanding language deterioration in bilingual AD and PD can guide interventions geared toward offering better care for patients, such as the choice of a care facility, or the language in which a neuropsychological evaluation is performed. In addition, AD patients have been shown to respond well to communication interventions, such as eliminating distraction, using simple sentences, using yes/no questions, and not reducing speaking rate (Small, Gutman, Makela, & Hillhouse, 2003). Knowledge of how language deteriorates in L1 and L2 could be used to guide the identification and design of such strategies.

Additional Implications for Neurolinguistics

It is only in the 1980s that the role of the basal ganglia and the thalamus of the left hemisphere in language began to be rigorously investigated. Since, it is known that lesions of the basal ganglia of the left hemisphere can result in non-fluent aphasia, voice disorders, writing disorders, echolalia and perseveration (in Fabbro, 1999). The same lesions can also result in semantic and verbal paraphasias, which are usually associated with fluent aphasias (in Fabbro, 1999). This overlap in the symptoms resulting from lesions of the tempo-parietal cortex and from lesions of subcortical structures is apparent also when functions of the left thalamus are examined. Lesions of the left thalamus have resulted in anomias, verbal and semantic paraphasias, mild comprehension deficits, and disorders in reading, among others (in Fabbro, 1999). Crosson (1992) proposed a model of subcortical function in language. Basically, subcortical structures activate the language system. Once the frontal cortex is activated, frontal lobe areas control the construction of language "chunks". Words are selected at the semantic level through neural circuits involving the frontal cortex, the pulvinar, and the left posterior cortical areas. The motor program for the production of speech involve Broca's area and Wernicke's area, together with the arcuate fasciculus for communication between the two areas. Fabbro (1999) describes three cases of bilingual and multilingual aphasics with lesion to the basal ganglia. In all cases, each language was affected and it is concluded that the basal ganglia of the left hemisphere are involved in the regulation of language function in bilinguals, namely, the process of speech initiation and maintenance through the limbic-striato-thalamo-cortical loop, the construction of grammatical sentences, the semantic and phonemic control of the words to be uttered, and the most automatic aspects of the translation process. Finally, the basal ganglia appeared to play a role in switching from one element of language to the next, in language production (Fabbro, 1999). While switching between languages was not observed in our study, the PD data provides converging evidence for the role of subcortical structures in sustaining both L1 and L2 grammar.

Summary and Future Directions

This study was the first to examine picture description and past tense generation in samples of bilingual young and older adults, and AD and PD patients. Aging had little effect on elicited speech and verb inflection. AD affected lexical processing more than grammatical processing in L1, and L1 more than L2. PD, by contrast, was associated with greater grammatical than lexical impairment in L1, and both grammatical and lexical difficulties in L2. These results provide support for the declarative-procedural model of the lexicon and grammar in L1, but not in L2. Challenges were discussed to the testability of the model, including overlap in the neural substrates of declarative and procedural memory, and interactions between the lexicon and grammar. Results from this study do not yield a simple answer to the question of how language deteriorates in AD and PD based on the neuropathology of these diseases, but indicate that AD and PD may affect an L1 and an L2 differently. The results show that it cannot be assumed that a patient always performs best in L1 on a neuropsychological or neurological evaluation, or that language preference is indicative of language ability. The PD results additionally provide evidence consistent with a role for subcortical structures in L1 and L2 grammar.

Future research may employ a longitudinal design to compare L1 versus L2 deterioration over time in bilingual AD and PD patients. This would be ideal to test the declarative-procedural model of the lexicon and grammar because it would allow for an examination of L1 and L2 in patients who have had extensive formal education in L2, but limited conversational experience. It is in these patients that the distinction between L1 grammar depending greatly on procedural memory and L2 grammar depending mostly on procedural memory is likely to be largest and therefore most detectable. Another definitely fruitful avenue for future research would be to examine the relative contribution of working memory, inhibitory processes, and processing speed, to lexical and grammatical processing in L1 and L2, in aging and age-related diseases. Finally, an interesting question is whether bilingual healthy older adults and bilingual AD or PD patients differ from their monolingual counterparts. Being bilingual may confer an advantage and immunize to some degree against linguistic decline, or alternatively, it may lead to greater decline because cognitive resources, such as inhibitory processes, have to be divided among two languages.

Conclusion

In conclusion, much of how aging and age-related diseases affect L1 and L2 remains to be uncovered. The results from this study suggest that aging has little impact on the lexicon and grammar, in L1 and L2, as tested with picture description and verb inflection. The findings converge with those in the literature in showing that AD leads to greater lexical than grammatical impairments, and that PD is associated with greater grammatical than lexical deficits, in an L1. The results in L2 suggest that AD may have a greater impact on L1 than on L2, and that PD equally impacts L1 and L2. These findings are preliminary, as this was the first examination of picture description and past tense generation in bilingual healthy older adults and AD and PD patients. It is hoped that they will stimulate further research into bilingual aging and language deterioration in AD and PD, which offers unique insight into brain-memory-language connections and may help guide the development of strategies to improve communication in older adults and in patient populations.

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Appendix A:
Health Screening and Language Screening Questionnaires

Note: These are in French only, because the researcher screening the participants (L. Cameli), who also performed the testing in French, pretended to speak only French so that any code-switching behavior in the AD patients, if observed, could be correctly interpreted as inappropriate. The researcher who tested the patients in English (S. Kousaie) pretended to speak only English, for the same reason.

Interviewer: ___________________ Date: ________________

Plans de vacances:________

Nom:
Date de naissance: Age:
Numéro de tél: Lateralisation manuelle:
Heures: Sexe:
Source:

Questionnaire sur la Santé

- Avez-vous maintenant, ou avez-vous eu par le passé, des problèmes de

  - Vision: Myope (ne peut voir loin) / Presbyte (ne peut voir proche)
  Lunettes / Verres de contact
  Cataracte: Gauche / Droite
  Daltonien(ne): NON / OUI

  - Audition: NON / OUI
  Appareil: Gauche / Droite

- Avez-vous déjà été **inconscient(e) ou eu une blessure à la tête**? NON / OUI
  Raison:
  Durée:
  Traitement et Résultat:

- Avez-vous été **gravement malade ou hospitalisée** au cours des derniers 6 mois? NON / OUI
  Raison:
  Traitement:

Souffrez-vous présentement, ou avez-vous déjà souffert, un

- Accident cérébro-vasculaire NON / OUI Quand?
- Maladie cardiaque NON / OUI (infection myocarde, angine, artères bloquées)
- Haute pression artérielle NON / OUI Controllée?
- Cholesterol élevé NON / OUI
- Pontage coronarien NON / OUI

- Chirurgie NON / OUI
- Crises d'épilepsie NON / OUI Age: Freq:
  Cause: Traitement:
- Epilepsie NON / OUI
- Diabète NON / OUI Type I / Type II Age:
  Insuline? NON / OUI Traitement:
- Maladie de la Thyroide NON / OUI
- Mal de tête fréquent NON / OUI Tension / migraine
- Etourdissements NON / OUI
- Difficulté à marcher/ perte de balance NON / OUI
- Maladie grave (e.g. foie, reins) NON / OUI
- Troubles neurologiques NON / OUI
- Avez-vous été exposé (e) à des produits toxiques?
  NON / OUI

  Depression NON / OUI
- Anxiété NON / OUI
- (Autres) difficulties psychologiques? NON / OUI

Medicaments

Type Raison Age/Durée/Dose

Prenez-vous des hormones, ou stéroides?

Alcool, Tabac, Drogues

	Quantité (par jour/semaine/mois/an)		
	Présent	Passé	Age
Alcool			
Tabac			paquets/jour (exclude if 20 pack-years)
Drogues			

Présentement, avez-vous des problèmes de:

- Concentration / Attention NON / OUI Nature:
- Mémoire NON / OUI Nature:
- Cherchez-vous vos mots NON / OUI Nature:

Quel est l' état de votre **santé en général,** sur une échelle de 1 a 5 ? 1 2 3 4 5
Adresse:

Questionnaire sur les langues

Personne présente si le sujet est un patient:

Enfance

A quel endroit êtes-vous né(e)?

Quand vous étiez enfant, quelle langue parliez-vous à la maison?
Avec votre Père? Mère?
Est-ce que d'autres personnes habitaient avec vous? (X)
Parliez-vous d'autres langues à la maison?
Quelles langues?
Avec qui?
Quand?

Quelle(s) langue parle (ou parlait) votre mère?
Vous a-t-elle déjà parlé dans cette langue?
Parlait-t-elle à votre père dans cette langue?
Parlait-t-elle à d'autres personnes dans cette langue devant vous?

Quelle(s) langue parle (ou parlait) votre père?
Vous a-t-il déjà parlé dans cette langue?
Parlait-t-il à votre mère dans cette langue?
Parlait-t-il à d'autres personnes dans cette langue devant vous?

Quelle(s) langue parle (ou parlais) X?
Vous a-t-il (elle) deja parlé dans cette langue?
Parlait-t-il (elle) à votre père dans cette langue?
Parlait-t-il (elle) à votre mère dans cette langue?
Parlait-t-(elle) à d'autres personnes dans cette langue devant vous?

Est-ce que quelqu'un d'autre s'est occupé de vous (une tante, gardienne)?
Quelle langue parlait-il (elle)?

Avez-vous des frères, soeurs?
Quelle langue parliez-vous le plus souvent avec eux (il, elle)?
Parliez-vous d'autres langues avec eux (il, elle)?

Dans votre parenté, est-ce que certain parents (oncles, tantes, cousins) vous parlaient dans une autre langue que votre langue maternelle ou paternelle?

Les côtoyez-vous souvent?

Aviez-vous des amis avec qui vous aimiez jouer quand vous étiez petit (petite) (e.g., des petits voisins)?

Quelle langue(s) parliez-vous avec eux?

Parliez-vous d'autres langues avec eux?

Combien d'années d'étude avez-vous complétées?

Avez-vous eu, pendant vos études, des difficultés d'apprentissage dans certaines matieres?

Avez-vous déjà doublé une année?

Etiez-vous bon(ne) en Francais? Anglais?

A l' école, quelle était la langue d'enseignement?

Aviez-vous des cours dans une autre langue?

Quelle langue parlaient les enfants à l' école entre eux?

Quelle langue parliez-vous avec vos amis?

Quelle langue parliez-vous avec vos voisins pendant ces années?

A l' université, quelle était la langue d'enseignement?

Aviez-vous des cours dans une autre langue?

Quelle langue parlaient les élèves à l' école entre eux?

Quelle langue parliez-vous avec vos amis?

Est-ce que vous avez travaillé pendant vos études?

Quel emploi occupiez-vous?

Quelle langue(s) parliez-vous au travail?

Quelle a étée votre occupation par la suite?

Quel emploi occupiez-vous?

Quelle langue(s) parliez-vous au travail?

Pendant combien d' années avez-vous travaillé?

Avez-vous parlé d' autres langues pendant ces années?

Vous-etes-vous marié (e), ou avez-vous déjà co-habité avec quelqu'un?

Quelle(s) langue(s) parle (parlais) cette personne?

Avez-vous co-habité avec quelqu'un d'autre? (après être parti(e) de chez vos parents)

Quelle(s) langue(s) parle (parlais) cette personne?

Avez-vous des enfants?

Quelle(s) langue(s) parlez-vous avec eux?

Avez-vous déja parlé une autre langue avec eux?

Avez-vous déjà habité dans un autre pays?

Quelle(s) était(ent) la(les) langue(s) du pays? Quelle(s) langue(s) parliez-vous?

Quelle langue parlez-vous le plus souvent maintenant?

Avec qui?

Parlez-vous d'autres langues?

A chaque jour? Semaine? Mois?

Lisez-vous dans d'autres langues?

A chaque jour? Semaine? Mois?

L2

Ou avez-vous appris L2?

Comment avez-vous appris L2?

De quelle facon?

En classe?

Par des listes? Ou de la pratique?

Pourquoi avez vous appris L2?

Vos connaissances: (pauvre – bon- excellent)

	L1	L2
Comprehension		
Parle		
Lire		
Ecrire		

Dans quelle langue vous sentez-vous le plus confortable? Dans quelle langue pensez-vous?

Est-ce que vous trouvez que vous devez vous forcer pour parler ou ecrire dans votre L2?

Est-ce que cela demande plus d' effort que pour votre langue(s) maternelle(s)?

Pendant combien d' années avez-vous pratique L2?

Avez-vous déjà utilise L2 en-dehors de votre travail?

Pour votre travail, ulitiziez vous votre L2?

A chaque jour? Semaine? Mois?

Appendix B:
Consent Forms

Jewish General Hospital
Department of Clinical Neurosciences
Study of Implicit Linguistic Competence
and Metalinguistic Knowledge
in Alzheimer's and Parkinson's Diseases

Consent Form for the Jewish General Hospital
Study of Implicit Linguistic Competence and Metalinguistic Knowledge
In Alzheimer's and Parkinson's Diseases

Purpose of the Study:

This study will compare the performance of bilingual patients with Alzheimer's disease and Parkinson's disease to that of healthy bilingual elderly adults on tests of verbal ability performed in each of the bilingual's languages. The results will help clarify the nature of the changes in language processing that occur as a result of Alzheimer's disease and Parkinson's disease.

Details of the Study:

The study will take place in the Neurophysiology Laboratory of the Jewish General Hospital or of Concordia University. Upon my request, the study may instead take place in my home or at the Douglas Hospital. The study will require 3 visits that should last approximately 2 hours each.

On one visit, I will be asked to perform 4 tests of memory as follows: 1) I will try to remember abstract designs. 2) I will try to remember a list of words. 3) I will learn to read words that are printed backward. 4) I will name the location of a star that appears on a computer screen. On the other two visits, I will be given these 2 tests in my native and second language: 1) Free Speech: I will be asked to describe an image. 2) Verb Tense task: I will hear sentences like "Every day I plant a tree. Just like every day, yesterday I ____ a tree" and try to generate the verb that best fits (in this example, "planted"). For most tests, I will be looking at a computer screen. My Free Speech will be recorded and name will not appear on the audiotape. What I will say on the tape will be transcribed, and again, my name will not appear on the transcription. The audiotape will be destroyed 7 years after the study is completed.

I understand that while I may not be able to answer every question perfectly, the most important thing will be that I will try to do my best. This test is for research purposes only. It is not diagnostic, meaning that it will not yield any results about myself. I understand that my individual results will not be provided to me but that I will be informed of the general findings of the study.

March 2004

Jewish General Hospital
Jewish General Hospital
Department of Clinical Neurosciences
Study of Implicit Linguistic Competence
and Metalinguistic Knowledge
in Alzheimer's and Parkinson's Diseases

Consent Form for the Jewish General Hospital
Study of Implicit Linguistic Competence and Metalinguistic Knowledge
In Alzheimer's and Parkinson's Diseases

Disadvantages and Risks of Participating in the Study:

It is possible that I will find some of the tasks boring or frustrating. In order to avoid this, I will be given a break whenever I like and will be offered refreshments.

Advantages to Participating in the Study:

The researchers hope to learn about the changes in linguistic competence (e.g., grammar) and knowledge (e.g., vocabulary) that occur with Alzheimer's or Parkinson's disease. Although this will not benefit me directly, this research could add to our scientific understanding of how language is affected by Alzheimer's disease and by Parkinson's disease.

Confidentiality:

All information about my participation is confidential and I will not be identified in any published report.

Compensation:

I will be given $15 at the end of each testing session as a token of appreciation for my time. I may discontinue participation at any point in the course of a session and will still receive $15.

Withdrawal from the Study:

I understand that my participation in this study is voluntary and, if I agree to participate, I may withdraw my consent and discontinue participation at any time without affecting my medical care.

March 2004
Jewish General Hospital

Jewish General Hospital
Department of Clinical Neurosciences
Study of Implicit Linguistic Competence
and Metalinguistic Knowledge
in Alzheimer's and Parkinson's Diseases

Consent Form for the Jewish General Hospital
Study of Implicit Linguistic Competence and Metalinguistic Knowledge
In Alzheimer's and Parkinson's Diseases

Patient Rights:

I have fully discussed and have been told of the purpose and procedure of this study and have had the opportunity to ask any questions.

The following is the name, address, and telephone number of the Hospital's Patient Representative, who is not associated with this study and to whom I may address my concerns about my rights as a participant in this study: Ms. Laurie Berlin, 3755 Côte Ste. Catherine Road, Montreal, Quebec, H3T 1E2; Tel: 340-8222 ext. 5833.

The following is the name, address, and telephone number of the researcher whom I may contact for answers to questions about the research or any adverse reactions which might occur:

Dr. Natalie Phillips, Dept. of Psychology, Concordia University, 7141 Sherbrooke Street West. Montreal, Quebec, H4B 1R6; Tel: 848-2218.

Signature:

I have been told about the contents of this consent form, have had the opportunity to ask questions, and agree to participate in this study. I do not give up any of my legal rights by signing this form.

All participants will receive a copy of this consent form.
Date: ____________________

____________________ Signature of Subject	____________________ Print Name
____________________ Signature of Caregiver (if subject is a patient)	____________________ Print Name
____________________ Signature of Investigator	____________________ Print Name
____________________ Signature of person explaining informed consent	____________________ Print Name

Hôpital Général Juif
Département de Neurosciences Cliniques
Étude de la Compétence Linguistique
Et Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et Parkinson

Formulaire de Consentement pour l'Étude de l'Hôpital Général Juif
Portant sur la Compétence Linguistique Et les Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et de Parkinson

Buts de l'étude:
Le but de cette étude est de comparer la performance de patients bilingues qui souffrent de la maladie d'Alzheimer ou de Parkinson à celle de personnes âgées bilingues en bonne santé avec des tests d'habileté verbale complétés dans chaque langue. Les résultats aideront à clarifier la nature des changements au niveau du langage qui surviennent avec la maladie d'Alzheimer ou de Parkinson.

Détails de l'étude:
L'étude aura lieu au Laboratoire de Neurophysiologie de l'Hôpital Général Juif ou de l'Université Concordia. Si je le demande, l'étude pourrait avoir lieu chez moi. L'étude demande 3 visites qui devraient durer approximativement 2 heures chacune.

Au cours d'une visite, on me demandera de compléter 4 tests de mémoire comme suit: 1) J'essaierai de me rappeller des dessins abstraits. 2) J'essaierai de me rappeller une liste de mots. 3) J'apprendrai à lire des mots qui sont imprimés à l'envers. 4) Je nommerai l'emplaçement d'une étoile qui apparaît sur un écran d'ordinateur. Lors des deux autres visites, on me fera passer ces 2 tests dans ma langue maternelle et seconde: 1) Narration: On me demandera de décrire une image. 2) Conjugaison de Verbes: J'entendrai des phrases comme: "Tous les jours, Bernard lit le journal. On a sonné à la porte hier pendant que Bernard ____ le journal" et on me demandera de dire le verbe qui manque (ici, "lisait"). Pour la majorité des tests, je regarderai un écran d'ordinateur. Ma Narration sera enregistrée et mon nom n'apparaitra pas sur la cassette audio. Ce que je dirai et qui sera enregistré sera transcrit, et mon nom n'apparaîtra pas sur la transcription. La cassette sera détruite 7 ans après la fin de l'étude.

Je comprends que même si je ne peux répondre parfaitement à toutes les questions, l'important est de faire de mon mieux. Ce test est pour la recherche seulement. Il n'est pas diagnostique d'aucune façon, ce qui veut dire qu'il ne donnera aucune information à mon sujet. Je comprends que mes résultats individuels ne me seront pas divulgués mais que je serai informé(e) des résultats généraux de l'étude.

Mars 2004
Hôpital Général Juif

Hôpital Général Juif
Département de Neurosciences Cliniques
Étude de la Compétence Linguistique
Et Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et Parkinson

Formulaire de Consentement pour l'Étude de l'Hôpital Général Juif
Portant sur la Compétence Linguistique Et les Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et de Parkinson

Désavantages et Risques encourus en participant à l'Étude:

Il est possible que je trouve certaines tâches ennuyeuses ou pénibles. Afin d'éviter ceci, on me donnera une pause lorsque je le désirerai et on m'offrira des rafraîchissements.

Avantages de participer a l'Étude:

Les chercheurs espèrent en savoir plus sur les changements en compétence linguistique (ex. grammaire) et connaissances (ex. vocabulaire) qui surviennent des suites de la maladie d'Alzheimer où Parkinson. Même si cette étude ne me sera d'aucun bénéfice direct, cette recherche pourrait améliorer nos connaissances scientifiques concernant la manière par laquelle le langage est affecté par les maladies d'Alzheimer ou Parkinson.

Confidentialité:

Toute information sur ma participation est confidentielle et je ne serai pas identifié(e) dans aucune publication.

Compensation:

On me donnera $15 à la fin de chaque session en signe d'appréciation pour mon temps. Je peux discontinuer ma participation n'importe quand pendant la session et je recevrai quand même $15.

Retrait de l'Étude:

Je comprends que ma participation à cette étude est volontaire et que si j'accepte de participer, je peux retirer mon consentement et discontinuer ma participation à n'importe quel moment sans affecter mes soins médicaux.

Mars 2004
Hôpital Général Juif

Hôpital Général Juif
Département de Neurosciences Cliniques
Étude de la Compétence Linguistique
Et Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et Parkinson

**Formulaire de Consentement pour l'Étude de l'Hôpital Général Juif
Portant sur la Compétence Linguistique Et les Connaissances Métalinguistiques
Dans les Maladies d'Alzheimer et de Parkinson**

Droits des Patients:
J'ai entièrement discuté et j'ai été informé(e) des buts et procédures de cette étude, et j'ai eu l'opportunité de poser toute question.

Voici le nom, adresse, et numéro de téléphone de la Représentante des Patients(es) de l'Hôpital, qui n'est pas associée a cette étude et à qui je peux adresser toute inquiétude reliée à mes droits en tant que participant(e) dans cette étude: Mlle Laurie Berlin, 3755 Ch. De la Côte Ste. Catherine, Montréal, Québec, H3T 1E2; Tel: 340-8222 ext. 5833.

Voici le nom, adresse, et numéro de téléphone de la chercheuse que je peux contacter pour des réponses a des questions reliées à la recherche ou réactions adverses quelconques: Dr. Natalie Phillips, Dép. de Psychologie, Université Concordia, 7141 Sherbrooke Ouest. Montréal, Québec, H4B 1R6; Tel: 848-2218.

Signature:
J'ai été informé(e) du contenu de ce formulaire de consentement, j'ai eu l'opportunité de poser des questions, et j'accepte de participer a cette étude. Je ne renonce à aucun de mes droits légaux en signant ce formulaire.

Tous les participants(es) recevront une copie de ce formulaire de consentement.

Date: ____________________

____________________ ____________________

Signature du Sujet Écrire en lettres moulées

____________________ ____________________

Signature du Gardien (si le sujet est un(e) patient(e))Écrire en lettres moulées

____________________ ____________________

Signature du Chercheur Écrire en lettres moulées

____________________ ____________________

Signature de la Personne ayant expliqué Le Formulaire de Consentement

Appendix C :
Demographic, Linguistic, and Medical Information
On Patients and their Controls

AD Patients	Healthy Control
AD 1 *<u>L1</u>:* French *<u>MMSE</u>*: 16 *<u>Age</u>*: 83 *Handedness*: Right *<u>Years of Education</u>*: 8 *Gender*: Male *Occupation*:Bus driver, sales representative *<u>Age of L2 learning</u>*: 15 *<u>Method</u>*: Friends, golf course, army *<u>Current frequency of L2 use</u>*: 60% *<u>Usage</u>*: Wife is English, children, family and friends, TV *Medication*: Aricept	*NC 7N* *<u>L1</u>:* French *<u>Age</u>*: 72 *Handedness*: Right *<u>Years of Education</u>*: 12 *Gender*: Female *Occupation*: Clerk *<u>Age of L2 learning</u>*: 20 *<u>Method</u>*: Worked mostly in English *<u>Current frequency of L2 use</u>*: 55% *<u>Usage</u>*: Boyfriend speaks English, friends *Medication*: None
AD 2 *<u>L1</u>*:French *<u>MMSE</u>*: 26 *<u>Age</u>*: 75 *Handedness*: Right *<u>Years of Education</u>*: 14 *Gender*: Male *Occupation*:Contractor in construction *<u>Age of L2 learning</u>*: 7 *<u>Method</u>*: School, friends *<u>Current frequency of L2 use</u>*: 20% *<u>Usage</u>*: Family, friends (wife is English-speaking but couple speaks French together), TV, reading. *Medication*: Paxil	*NC 2* *<u>L1</u>:* French *<u>Age</u>*: 74 *Handedness*: Right *<u>Years of Education</u>*: 15 *Gender*: Female *Occupation*: Legal secretary *<u>Age of L2 learning</u>*: 18 *<u>Method</u>*: Last year of high school English, night classes in English *<u>Current frequency of L2 use</u>*: 50% *<u>Usage</u>*: Activities, neighborhood, ex-husband was English-speaking *Medication*: Elavil for sleep
AD 3 *<u>L1</u>:* French *<u>MMSE</u>*: Not avail *<u>Age</u>*: 58 *Handedness*: Right *<u>Years of Education</u>*: 12 *Gender*: Male *Occupation*:Sales of industrial products *<u>Age of L2 learning</u>*: 15 *<u>Method</u>*: Technical training at work *<u>Current frequency of L2 use</u>*: 50% *<u>Usage</u>*: Work, friends *Medication*: Aricept, Asaphen,Clonazepam	*NC 12* *<u>L1</u>:* English *<u>Age</u>*: 65 *Handedness*: Right *<u>Years of Education</u>*: 18 *Gender*: Female *Occupation*: Real estate, foreign business *<u>Age of L2 learning</u>*: 19 *<u>Method</u>*: School in Paris at 19 *<u>Current frequency of L2 use</u>*: 40% *<u>Usage</u>*: Activities, neighborhood, friends *Medication*: None
AD 4 *<u>L1</u>:* English *<u>MMSE</u>*: Not avail *<u>Age</u>:* 82 *Handedness*: Ambidextrous *<u>Years of Education</u>*: 10 *Gender*: Male *Occupation*:Machinist, sales industrial prod *<u>Age of L2 learning</u>*: 6 *<u>Method</u>*: French school *<u>Current frequency of L2 use</u>*: 60% *<u>Usage</u>*: Wife is French-speaking, reads French paper *Medication*: Aricept, Asaphen,Clonazepam	*NC 5N* *<u>L1</u>:* French *<u>Age</u>*: 70 *Handedness*: Right *<u>Years of Education</u>*: 16 *Gender*: Female *Occupation*: Clerk *<u>Age of L2 learning</u>*: 16 *<u>Method</u>*: Commercial course and work *<u>Current frequency of L2 use</u>*: 35% *<u>Usage</u>*: Boyfriend speaks English, friends, reading, TV *Medication*: None

AD Patients (...continued)	Healthy Control
AD 5 *L1*: French *MMSE*: 23 *Age*: 67 *Handedness*: Right *Years of Education*: 14 *Gender*: Female *Occupation*: Executive at electrical co. *Age of L2 learning*: 17 *Method*: Language college *Current frequency of L2 use*: 33% *Usage*: Son's girlfriend is English-speaking, watches TV in English only *Medication*: Aricept	*NC 5* *L1*: French *Age*: 66 *Handedness*: Right *Years of Education*: 16 *Gender*: Female *Occupation*: Receptionist *Age of L2 learning*: 20 *Method*: School, work *Current frequency of L2 use*: 30% *Usage*: Studies full-time at English Univ. *Medication*: None
AD 6 *L1*:French, L2: Hebrew, Italian *Age*: 81 *Handedness*: Right *MMSE*: 18 *Years of Education*: 11 *Gender*: Female *Occupation*:Housewife *Age of L2 learning*: 18 *Method*: School, neighbors, children *Current frequency of L2 use*: 50% *Usage*: Children, caregivers, TV, reading *Medication*: Aricept, Memantine, Lozide, Coversyl, Pravastatin	*NC 8* *L1*: French *Age*: 68 *Handedness*: Right *Years of Education*: 18 *Gender*: Female *Occupation*: Psychologist *Age of L2 learning*: 8 *Method*: School, bilingual university *Current frequency of L2 use*: 50% *Usage*: Friends, neighborhood, *Medication*: None
AD 7 *L1*: French *MMSE*: 27 *Age*: 80 *Handedness*: Right *Years of Education*: 16 *Gender*: Male *Occupation*:Teacher/mechanics in Army *Age of L2 learning*: 15 *Method*: High school, then army *Current frequency of L2 use*: 80% *Usage*: Wife is English-speaking, children, family and friends, TV, reading *Medication*: Aricept	*NC 1* *L1*: French *Age*: 72 *Handedness*: Right *Years of Education*: 18 *Gender*: Female *Occupation*: Mathematician, housewife *Age of L2 learning*: 16 *Method*: High school immersion (50-50) *Current frequency of L2 use*: 50% *Usage*: Husband is English-speaking, activities, neighborhood, family *Medication*: None
AD 8 *L1*: French *MMSE*: 24 *Age*: 82 *Handedness*: Ambidextrous *Years of Education*: 13 *Gender*: Male *Occupation*:Soldier *Age of L2 learning*: 8 *Method*: High school then army *Current frequency of L2 use*: 50% *Usage*: TV, reading, friends, kids, social *Medication*: None mentioned	*NC 6* *L1*: French *Age*: 70 *Handedness*: Ambidextrous *Years of Education*: 15 *Gender*: Male *Occupation*: Engineer *Age of L2 learning*: 12 *Method*: School as immigrated to Canada *Current frequency of L2 use*: 90% (but 6 years ago, 90% L1; because of retirement) *Usage*: Wife (speak both L1 and L2), friends, shopping *Medication*: None

PD Patients	Healthy Control
PD 1 *<u>L1</u>:* French *<u>Hoehn & Yahr</u>*: 3.0 *<u>Age</u>*: 56 *Handedness*: Right *<u>Years of Education</u>*: 12 *Gender*: Female *Occupation*:Buyer, accountant for bank *<u>Age of L2 learning</u>*: 16 *<u>Method</u>*: Last year high school was English *<u>Current frequency of L2 use</u>*: 50% *<u>Usage</u>*: Husband is English,people from work *Medication*: Permax, Paxil, Levodopa, Sinemet	*NC 2N* *<u>L1</u>:* French *<u>Age</u>*: 52 *Handedness*: Right *<u>Years of Education</u>*: 20 *Gender*: Male *Occupation*: Researcher *<u>Age of L2 learning</u>*: 20 *<u>Method</u>*: University course, work *<u>Current frequency of L2 use</u>*: 33% *<u>Usage</u>*: Work, reading, TV 50% English *Medication*: None
PD 2 *<u>L1</u>*:French *<u>Hoehn & Yahr</u>*: 1.5 *<u>Age</u>*: 59 *Handedness*: Right *<u>Years of Education</u>*: 11 *Gender*: Female *Occupation*: Secretary *<u>Age of L2 learning</u>*: 15 *<u>Method</u>*: School, English neighbors, moved to Toronto at age 15 *<u>Current frequency of L2 use</u>*: 50% *<u>Usage</u>*: Friends, TV, reading *Medication*: Amantadine, Fosemax	*NC 7* *<u>L1</u>:* French *<u>Age</u>*: 63 *Handedness*: Right *<u>Years of Education</u>*: 15 *Gender*: Female *Occupation*: Clerk *<u>Age of L2 learning</u>*: 20 *<u>Method</u>*: Language school *<u>Current frequency of L2 use</u>*: 50% *<u>Usage</u>*: Friends, readings, TV *Medication*: None
PD 3 *<u>L1</u>:* English *<u>Hoehn & Yahr</u>*: 2.0 *<u>Age</u>*: 55 *Handedness*: Right *<u>Years of Education</u>*: 24 *Gender*: Male *Occupation*: Librarian (MA in Comput sc.) *<u>Age of L2 learning</u>*: 20 *<u>Method</u>*: Degree at French University *<u>Current frequency of L2 use</u>*: 30% *<u>Usage</u>*: French neighborhood, work *Medication*: Neurotin,Amantadine, Effexor	*NC 1N* *<u>L1</u>:* French *<u>Age</u>*: 62 *Handedness*: Left *<u>Years of Education</u>*: 16 *Gender*: Male *Occupation*: Jail guardian *<u>Age of L2 learning</u>*: 14 *<u>Method</u>*: School, summer work *<u>Current frequency of L2 use</u>*: 40% *<u>Usage</u>*: Friends, newspaper, TV *Medication*: None
PD 4 *<u>L1</u>:* French *<u>Hoehn & Yahr</u>*: Not avail. *<u>Age</u>:* 69 *Handedness*: Right *<u>Years of Education</u>*: 13 *Gender*: Male *Occupation*: Accounting clerk *<u>Age of L2 learning</u>*: 18 *<u>Method</u>*: Neighbors *<u>Current frequency of L2 use</u>*: 40% *<u>Usage</u>*: English exercise center, reading, internet *Medication*: Levadopa, Comtan	*NC 5N* *<u>L1</u>:* French *<u>Age</u>*: 70 *Handedness*: Right *<u>Years of Education</u>*: 16 *Gender*: Female *Occupation*: Clerk *<u>Age of L2 learning</u>*: 16 *<u>Method</u>*: Commercial course and work *<u>Current frequency of L2 use</u>*: 35% *<u>Usage</u>*: Boyfriend speaks English, friends, reading, TV *Medication*: None

PD Patients (...continued)	Healthy Control
PD 5 *L1:* French *Hoehn & Yahr*: 2.0 *Age*: 75 *Handedness*: Right *Years of Education*: 11 *Gender*: Female *Occupation*: Secretary *Age of L2 learning*: 18 *Method*: Work and with husband *Current frequency of L2 use*: 50% *Usage*: English with son and his family (live in same house) *Medication*: Amantadine	*NC 1* *L1:* French *Age*: 72 *Handedness*: Right *Years of Education*: 18 *Gender*: Female *Occupation*: Mathematician, housewife *Age of L2 learning*: 16 *Method*: High school immersion (50-50) *Current frequency of L2 use*: 50% *Usage*: Husband is English-speaking, activities, neighborhood, family *Medication*: None
PD 6 *L1:*French *Hoehn & Yahr*: 3.0 *Age*: 71 *Handedness*: Right *Years of Education*: 13 *Gender*: Female *Occupation*: Family business, wine import *Age of L2 learning*: 20 *Method*: School and work *Current frequency of L2 use*: 30% *Usage*: Reads English paper daily, clients at work *Medication*: Not avail.	*NC 7N* *L1:* French *Age:* 72 *Handedness*: Right *Years of Education*: 12 *Gender*: Female *Occupation*: Clerk *Age of L2 learning*: 20 *Method*: Worked mostly in English *Current frequency of L2 use*: 55% *Usage*: Boyfriend speaks English, friends *Medication*: None
PD 7 *L1:* French *Hoehn & Yahr*: 2.0 *Age*: 58 *Handedness*: Ambidextrous *Years of Education*: 17 *Gender*: Male *Occupation*: Engineer, real estate agent *Age of L2 learning*: 20 *Method*: Caddy in summer, work at IBM *Current frequency of L2 use*: 33% *Usage*: Work *Medication*: Permax	*NC 4N* *L1:* French *Age*: 59 *Handedness*: Right *Years of Education*: 20 *Gender*: Male *Occupation*: Engineer *Age of L2 learning*: 20 *Method*: University courses in English *Current frequency of L2 use*: 70% *Usage*: Wife is English-speaking, friends, newspaper, TV. *Medication*: None
PD 8 *L1:* English *Hoehn & Yahr*: 2.5 *Age:* 79 *Handedness*: Right *Years of Education*: 16 *Gender*: Male *Occupation*: Engineer *Age of L2 learning*: 30 *Method*: degree at French University *Current frequency of L2 use*: 30% *Usage*: Friends *Medication*: Levadopa	*NC 2* *L1:* French *Age*: 74 *Handedness*: Right *Years of Education*: 15 *Gender*: Female *Occupation*: Legal secretary *Age of L2 learning*: 18 *Method*: Last year of high school English, night classes in English *Current frequency of L2 use*: 50% *Usage*: Activities, neighborhood, ex-husband was English-speaking *Medication*: Elavil for sleep

Appendix D:
The RAVLT and BEM

Pre Post Fup NC

Name:______________________

Date:______________________

Rey Auditory Verbal Learning Test (RAVLT)
Form 1 (Learning List A)

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
drum ___	drum ___	drum ___	drum ___	drum ___
curtain ___	curtain ___	curtain ___	curtain ___	curtain ___
bell ___	bell ___	bell ___	bell ___	bell ___
coffee ___	coffee ___	coffee ___	coffee ___	coffee ___
school ___	school ___	school ___	school ___	school ___
parent ___	parent ___	parent ___	parent ___	parent ___
moon ___	moon ___	moon ___	moon ___	moon ___
garden ___	garden ___	garden ___	garden ___	garden ___
hat ___	hat ___	hat ___	hat ___	hat ___
farmer ___	farmer ___	farmer ___	farmer ___	farmer ___
nose ___	nose ___	nose ___	nose ___	nose ___
turkey ___	turkey ___	turkey ___	turkey ___	turkey ___
color ___	color ___	color ___	color ___	color ___
house ___	house ___	house ___	house ___	house ___
river ___	river ___	river ___	river ___	river ___

TOTAL	_____	_____	_____	_____	_____
Time:	_____	_____	_____	_____	_____

Total Score _____

(Updated: 15 Dec. 99)

List B (Interference)		List A (After Interference)		List A (30-min Delayed Recal	
desk	_____	drum	_____	drum	_____
ranger	_____	curtain	_____	curtain	_____
bird	_____	bell	_____	bell	_____
shoe	_____	coffee	_____	coffee	_____
stove	_____	school	_____	school	_____
mountain	_____	parent	_____	parent	_____
glasses	_____	moon	_____	moon	_____
towel	_____	garden	_____	garden	_____
cloud	_____	hat	_____	hat	_____
boat	_____	farmer	_____	farmer	_____
lamb	_____	nose	_____	nose	_____
gun	_____	turkey	_____	turkey	_____
pencil	_____	color	_____	color	_____
church	_____	house	_____	house	_____
fish	_____	river	_____	river	_____
Total	_____	**Total**	_____	**Total**	_____
Time	_____	**Time**	_____	**Time**	_____

RECOGNITION

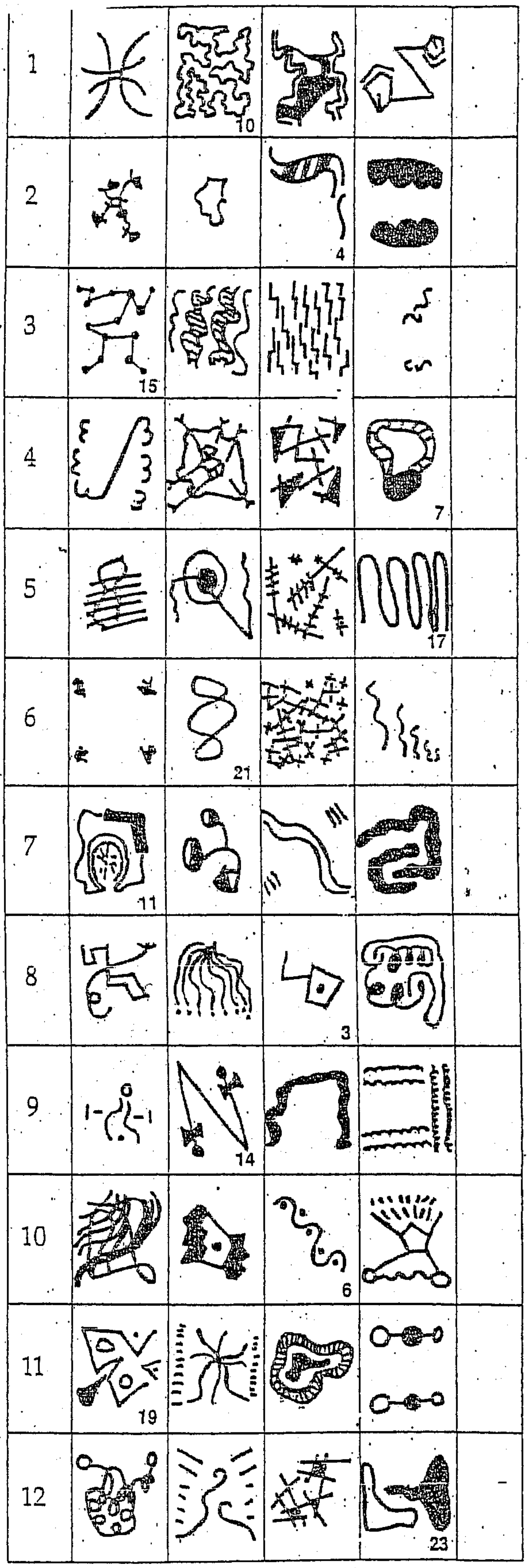
BUFFERS: **bicycle** _____ **spoon** _____

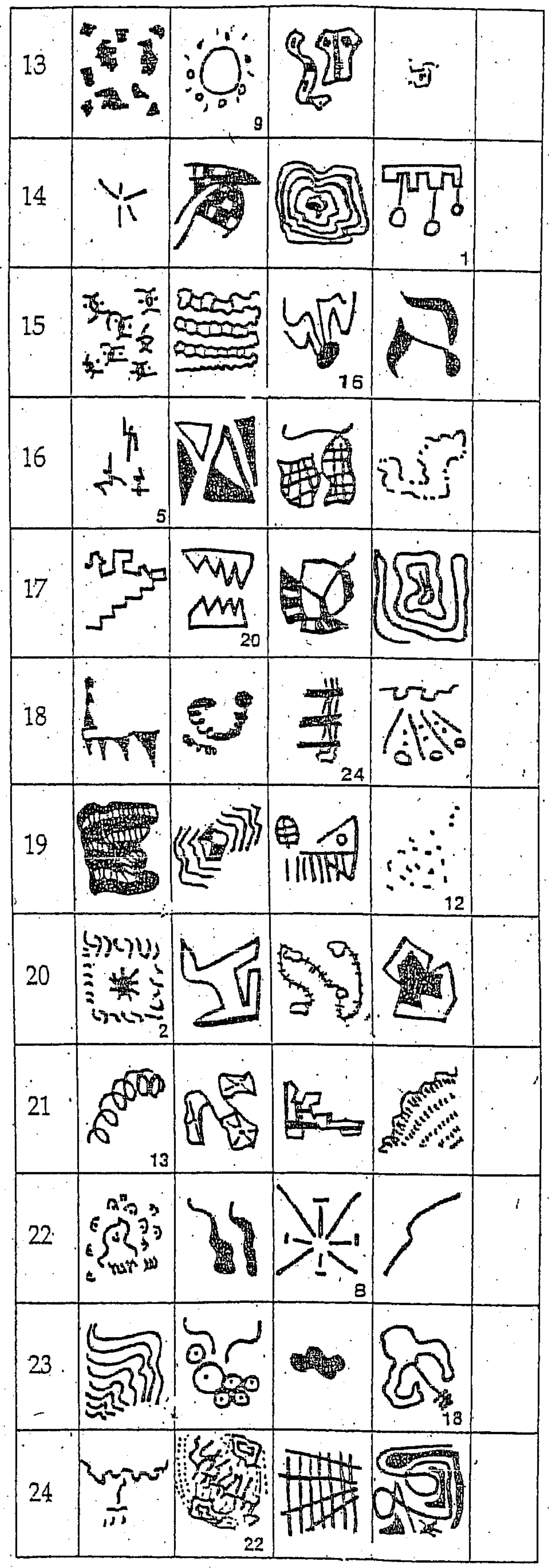
bell	_____	[1]thumb	_____	[1]crayon	_____	**garden**	_____
[1]window	_____	[1]balloon	_____	<u>church</u>	_____	<u>glasses</u>	_____
hat	_____	<u>bird</u>	_____	**turkey**	_____	[2]stocking	_____
[1]barn	_____	<u>mountain</u>	_____	[2]fountain	_____	<u>shoe</u>	_____
<u>ranger</u>	_____	**coffee**	_____	<u>boat</u>	_____	[1]teacher	_____
nose	_____	[1]mouse	_____	[1]hut	_____	<u>stove</u>	_____
[2]weather	_____	**river**	_____	**parent**	_____	[2]nest	_____
school	_____	<u>towel</u>	_____	[1]ocean	_____	[1]children	_____
[1]hand	_____	**curtain**	_____	**farmer**	_____	**drum**	_____
<u>pencil</u>	_____	[1]flower	_____	[1]hose	_____	[1]toffee	_____
[1]home	_____	**color**	_____	<u>cloud</u>	_____	<u>lamb</u>	_____
<u>fish</u>	_____	<u>desk</u>	_____	**house**	_____	**Total List A**	_____
moon	_____	<u>gun</u>	_____	[2]stranger	_____	**Total List B**	_____

bold = list A
<u>underline</u> = list B

Misattributions _____ False Positive Errors _____

(Update: 15 Dec. 1999)





Appendix E:
Mirror-Reading Words

SESSION 1

SET 1

hygiene-quartet-desert ______
cradle-vacuum-penalty ______
airport-turkey-spider ______
lantern-racket-defect ______
puzzle-trailer-incline ______
ticket-puddle-helmet ______
remedy-picnic-octopus ______
murmur-balcony-trophy ______
poster-butcher-nozzle ______
allergy-legacy-harvest ______

SET 2

radish-peasant-alcohol ______
ticket-helmet-puddle ______
surgeon-lotion-guitar ______
poster-nozzle-butcher ______
rocket-banquet-gossip ______
hygiene-desert-quartet ______
warrior-margin-oyster ______
lantern-defect-racket ______
pyramid-ration-bandit ______
cradle-penalty-vacuum ______

SET 3

racket-defect-lantern ______
magnet-boulder-piston ______
hazard-carrier-matrix ______
vacuum-penalty-cradle ______
vector-infant-pickle ______
quartet-desert-hygiene ______
pigeon-acetone-holiday ______
butcher-nozzle-poster ______
ailment-visitor-empire ______
puddle-helmet-ticket ______

SET 4

quartet-hygiene-desert ______
martini-trader-radius ______
puddle-ticket-helmet ______
abdomen-mosaic-nickel ______
racket-lantern-defect ______
toilet-muzzle-shield ______
butcher-poster-nozzle ______
vinegar-railway-meadow ______
vacuum-cradle-penalty ______
meteor-temper-whiskey ______

SET 5

helmet-ticket-puddle ______
penalty-cradle-vacuum ______
candle-barber-jockey ______
zipper-rainbow-script ______
defect-lantern-racket ______
recruit-cabana-strike ______
nozzle-poster-butcher ______
antenna-sweater-garbage ______
desert-hygiene-quartet ______
voyage-tablet-eclipse ______

SESSION 2

SET 1

residue-kitten-cereal ______
defect-racket-lantern ______
priest-cushion-anagram ______
desert-quartet-hygiene ______
stereo-fabric-hustler ______
helmet-puddle-ticket ______
penalty-vacuum-cradle ______
agenda-garland-memoir ______
puppet-ghetto-beckon ______
nozzle-butcher-poster ______

SET 2

export-habitat-pastry ______
racket-defect-lantern ______
lecture-antique-nephew ______
butcher-nozzle-poster ______
ticket-puddle-helmet ______
caramel-steeple-outfit ______
hygiene-desert-quartet ______
parrot-tomato-reward ______
penalty-cradle-vacuum ______
starch-inmate-pulley ______

SET 3

defect-lantern-racket ______
twitch-imprint-sketch ______
desert-quartet-hygiene ______
pepper-convent-wallet ______
cradle-vacuum-penalty ______
napkin-buffalo-verdict ______
nozzle-poster-butcher ______
trigger-martian-danish ______
helmet-ticket-puddle ______
asylum-sphere-catcher ______

SET 4

lantern-racket-defect ______
clover-vitamin-walrus ______
shooter-clutch-gravity ______
poster-butcher-nozzle ______
founder-outline-coroner ______
quartet-desert-hygiene ______
clipper-pollen-border ______
vacuum-penalty-cradle ______
fantasy-parent-galaxy ______
puddle-ticket-helmet ______

SET 5

cottage-pillow-cherry ______
nozzle-butcher-poster ______
maniac-legion-recipe ______
hygiene-quartet-desert ______
recital-throne-kettle ______
helmet-puddle-ticket ______
cabinet-sparkle-inning ______
penalty-vacuum-cradle ______
costume-shrine-monkey ______
defect-racket-lantern ______

SESSION 3

SET 1

winner-heater-debris ______
vacuum-cradle-penalty ______
analogy-fusion-willow ______
lantern-defect-racket ______
foliage-helium-ranger ______
butcher-poster-nozzle ______
kidney-bristle-castle ______
quartet-hygiene-desert ______
sleeve-kennel-twister ______
ticket-helmet-puddle ______

SET 2

racket-lantern-defect ______
implant-needle-walnut ______
janitor-luggage-sponsor ______
poster-nozzle-butcher ______
lagoon-funnel-peanut ______
desert-hygiene-quartet ______
incense-streak-tangle ______
puddle-helmet-ticket ______
pillar-grammar-rabbit ______
cradle-penalty-vacuum ______

RECOGNITION		
vessel	Y	N
nozzle	**Y**	**N**
insult	Y	N
jaguar	Y	N
basket	Y	N
cradle	**Y**	**N**
icicle	Y	N
elastic	Y	N
ribbon	Y	N
poster	**Y**	**N**
butcher	**Y**	**N**
insect	Y	N
lounge	Y	N
refund	Y	N
hygiene	**Y**	**N**
hostess	Y	N
vacuum	**Y**	**N**
sausage	Y	N
diamond	Y	N
ticket	**Y**	**N**
penalty	**Y**	**N**
algebra	Y	N

SET 3
hammer-mammal-tunnel ______
penalty-vacuum-cradle ______
pasture-scotch-falcon ______
poster-butcher-nozzle ______
locker-package-umpire ______
racket-defect-lantern ______
battery-shiver-massage ______
desert-hygiene-quartet ______
barrier-furnace-hormone ______
ticket-puddle-helmet ______

SET 4
vacuum-cradle-penalty ______
mandate-gutter-python ______
hostage-sailor-plywood ______
nozzle-butcher-poster ______
hunger-inferno-launch ______
hygiene-quartet-desert ______
scandal-chorus-errand ______
puddle-ticket-helmet ______
breeze-lottery-statue ______
lantern-racket-defect ______

SET 5
miracle-doorway-apricot ______
helmet-puddle-ticket ______
canvass-salami-wreath ______
quartet-hygiene-desert ______
booklet-pardon-quarry ______
cradle-penalty-vacuum ______
ambush-channel-mineral ______
butcher-poster-nozzle ______
bicycle-harness-thesis ______
defect-racket-lantern ______

cabbage	Y	N
quartet	**Y**	**N**
hunter	Y	N
racket	**Y**	**N**
fungus	Y	N
lantern	**Y**	**N**
physics	Y	N
kernel	Y	N
puddle	**Y**	**N**
surgery	Y	N
violin	Y	N
poison	Y	N
desert	**Y**	**N**
muffler	Y	N
litter	Y	N
pension	Y	N
nugget	Y	N
helmet	**Y**	**N**
madman	Y	N
parcel	Y	N
defect	**Y**	**N**
rhythm	Y	N
pageant	Y	N

SESSION 1

SET 1

option-barbier-sifflet ________
sandale-panier-écluse ________
parloir-végétal-cadette ________
estomac-bonbon-oursin ________
larron-horaire-louange ________
moelle-beurre-parleur ________
pantin-diamant-robinet ________
dessein-soutane-coureur ________
lisière-rameur-session ________
banane-dragon-pilier ________

SET 2

beurre-parleur-moelle ________
drapeau-piscine-berger ________
bonbon-oursin-estomac ________
chèvre-fraise-marteau ________
pilier-dragon-banane ________
soutane-coureur-dessein ________
citadin-engrais-tortue ________
archet-paresse-pommier ________
écluse-panier-sandale ________
montre-céréale-matelot ________

SET 3

rameau-accueil-voilier ________
panier-écluse-sandale ________
bouchon-tambour-poupée ________
tuteur-cigale-cuisse ________
dragon-pilier-banane ________
vitrine-boxeur-falaise ________
coureur-soutane-dessein ________
mélodie-saleté-bambin ________
parleur-beurre-moelle ________
oursin-estomac-bonbon ________

SET 4

buffet-chariot-laquais ________
sandale-écluse-panier ________
laitier-orange-taudis ________
estomac-oursin-bonbon ________
serrure-bouquin-verdict ________
moelle-parleur-beurre ________
rêverie-volcan-amande ________
dessein-coureur-soutane ________
blague-grange-jumeau ________
banane-pilier-dragon ________

SET 5

écluse-sandale-panier ________
dédain-potion-bêtise ________
beurre-moelle-parleur ________
lavabo-chorale-blouse ________
pénurie-corbeau-fumeur ________
bonbon-estomac-oursin ________
poivre-carnet-dispute ________
soutane-dessein-coureur ________
spirale-arbitre-cachot ________
pilier-banane-dragon ________

SESSION 2

SET 1

coureur-dessein-soutane ________
raisin-mineur-clavier ________
oursin-bonbon-estomac ________
penseur-maillot-cendre ________
parleur-moelle-beurre ________
moineau-timbale-collet ________
dragon-banane-pilier ________
vétéran-auberge-fondue ________
panier-sandale-écluse ________
levier-peigne-effroi ________

SET 2

crochet-posture-souris ________
tricot-bétail-rivage ________
sandale-panier-écluse ________
estomac-bonbon-oursin ________
remise-mouton-alerte ________
moelle-beurre-parleur ________
marais-glande-potage ________
banane-dragon-pilier ________
étalage-gagnant-bobine ________
dessein-soutane-coureur ________

SET 3

pilier-banane-dragon ________
délice-skieur-affiche ________
écluse-sandale-panier ________
harnais-lutteur-farine ________
bonbon-estomac-oursin ________
renard-graine-crayon ________
beurre-moelle-parleur ________
coussin-cochon-gouffre ________
soutane-dessein-coureur ________
buisson-sorcier-salade ________

SET 4

cabane-agneau-punaise ________
coureur-soutane-dessein ________
mouette-censure-biscuit ________
oursin-estomac-bonbon ________
briquet-tablier-gérant ________
dragon-pilier-banane ________
jungle-senteur-cocotte ________
cantine-nageuse-brebis ________
panier-écluse-sandale ________
parleur-beurre-moelle ________

SET 5

sandale-écluse-panier ________
gibier-excuse-bibelot ________
banane-pilier-dragon ________
pharaon-refrain-sondage ________
voleur-attache-croquis ________
estomac-oursin-bonbon ________
moelle-parleur-beurre ________
préfet-sergent-flocon ________
dessein-coureur-soutane ________
grenier-agrafe-minéral ________

SESSION 3

SET 1

dragon-banane-pilier ________
carotte-sultan-charbon ________
pleurs-donjon-fermier ________
coureur-dessein-soutane ________
lièvre-soulier-narine ________
parleur-beurre-moelle ________
pédale-relais-charrue ________
oursin-bonbon-estomac ________
litière-horloge-légume ________
panier-sandale-écluse ________

SET 2

pilier-dragon-banane ________
rosier-comble-museau ________
soutane-coureur-dessein ________
écluse-panier-sandale ________
collier-boisson-antenne ________
bonbon-oursin-estomac ________
onguent-bonnet-berceau ________
souper-pèlerin-filtre ________
beurre-parleur-moelle ________
équité-maille-civière ________

RECOGNITION

sandale	**Y**	**N**
sentier	Y	N
culotte	Y	N
soutane	**Y**	**N**
pilier	**Y**	**N**
calotte	Y	N
moelle	**Y**	**N**
brigand	Y	N
javelot	Y	N
dessein	**Y**	**N**
lambeau	Y	N
gosier	Y	N
estomac	**Y**	**N**
rabbin	Y	N
caillou	Y	N
licence	Y	N
panier	**Y**	**N**
labeur	Y	N
boucle	Y	N
parleur	**Y**	**N**
laurier	Y	N
taillis	Y	N
écluse	**Y**	**N**

SET 3

oursin-estomac-bonbon ________
piquet-recrue-bouffon ________
panier-écluse-sandale ________
bandeau-casier-scalpel ________
palette-griffe-placard ________
dragon-pilier-banane ________
ruelle-haricot-gobelet ________
parleur-moelle-beurre ________
couteau-laitue-portier ________
coureur-soutane-dessein ________

SET 4

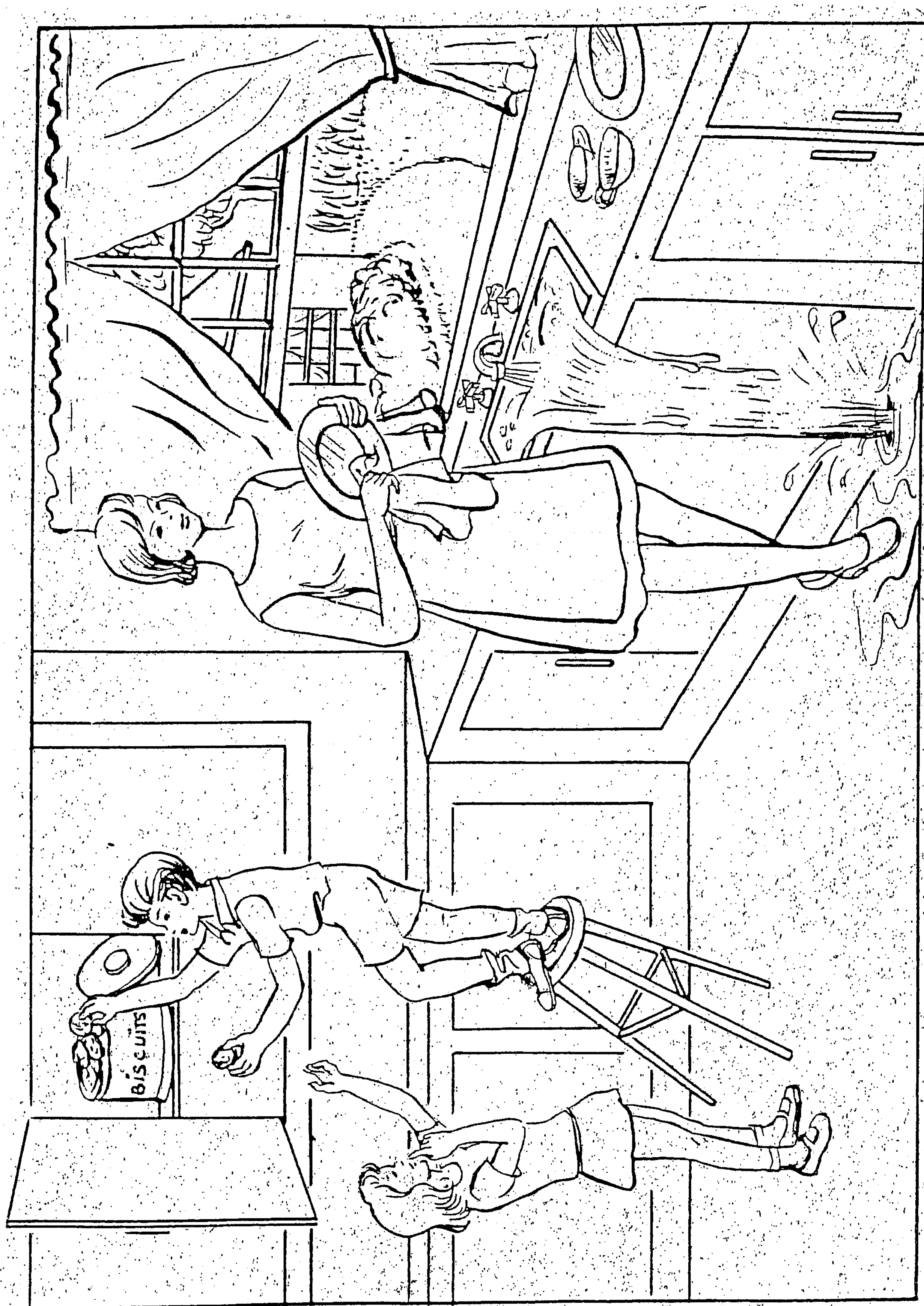
dessein-soutane-coureur ________
oeillet-copain-poteau ________
banane-dragon-pilier ________
pureté-caméra-commis ________
estomac-bonbon-oursin ________
grotte-boucher-parrain ________
sandale-panier-écluse ________
roseau-baronne-vertige ________
moelle-beurre-parleur ________
canard-rétine-chicane ________

SET 5

bonbon-oursin-estomac ________
pilier-dragon-banane ________
gourmet-pyjama-camelot ________
soutane-coureur-dessein ________
gicleur-vautour-bassin ________
cerise-goulot-recteur ________
écluse-panier-sandale ________
guitare-tartine-grelot ________
fardeau-cymbale-cabaret ________
beurre-parleur-moelle ________

harpon	Y	N
matrice	Y	N
banane	**Y**	**N**
prénom	Y	N
plainte	Y	N
dessert	Y	N
oursin	**Y**	**N**
puberté	Y	N
terrier	Y	N
trappe	Y	N
lucarne	Y	N
bonbon	**Y**	**N**
panique	Y	N
braise	Y	N
ordure	Y	N
dragon	**Y**	**N**
gitane	Y	N
mouche	Y	N
monceau	Y	N
beurre	**Y**	**N**
madrier	Y	N
coureur	**Y**	**N**

Appendix F :
Cookie Theft Picture


BISCUITS

Appendix G :
Sample of Picture Description
from Each Participant Group

Young Participant

L1

Bon, sur l'image, je vois une scène qui se passe dans une cuisine. Il y a un petit garçon qui est grimpé sur un tabouret pis il va se pêter la gueule en essayant de prendre des biscuits et pis d'en donner à sa soeur. En tout cas, je présume qu'ils sont frère et soeur. Puis, à droite, il y a une madame, peut-être la mère, qui est en train d'essuyer la vaisselle. Et elle est assez distraite qu'elle se rend pas compte que ses enfants sont en train de voler des biscuits et que son évier va déborder. Donc, je pense que c'est l'été. Il y a pas de neige dehors. Les enfants sont en culottes courte et en jupe. Puis, on dirait une mère de famille des années 50, avec son tablier et sa coupe de cheveux.

L2

On this nice little picture I see two kids, which I assume are brother and sisters, and I see the mother. And the little guy, the little boy, is standing on the stool and he's gonna fall down as he's trying to get some cookies in the cookie jar. And I think his sister wants some cookies. And their mother is washing the dishes and she looks a bit distracted because she doesn't realize her kids are trying to steal cookies and she doesn't realize the sink is full of water and there will be water everywhere soon. And it looks like it's summer because I look through the window and I don't see any snow and that's about it. She is drying a plate.

Older Adult

L1

Bon, je vois une femme qui est à près laver. Mais elle porte pas beaucoup attention parce qu'elle a l'air être dans la lune. L'eau coule dans l'évier, coule à terre. Les enfants sont, sont, le petit garçon est allé chercher la boîte de biscuits dans l'armoire, sur un tabouret. Puis le tabouret, il est seulement sur deux pattes plutôt que trois, alors il pourrait tomber. Et il y a la petite fille qui attend d'avoir son biscuit. Dans le, la maison a l'air en ordre et il y a juste un peu de vaisselle sur le comptoir. Il y a un jardin qui a l'air dans un bon état. Les rideaux sont bien.

L2

There is a mother with her two children. And she's washing the dishes, and she's not careful because the whole sink is overflowing, and she's in the clouds I guess, and the, also, she's not watching the children because he's going into the cookie jar and he's falling. He's not supposed to go up on that little stool, and the little girl is waiting for her cookies, as he took the cookie from the cookie jar. And everything is very tidy besides. There is two cups and one plate. And the garden seems tidy as well. Nice gardens. But the water is, I don't know how she could have left it.

AD Patient

L1

Il y a une petite fille qui essaie de regarder son garçon, un garçon enfin. Il est en train d'avoir une mauvaise situation. D'abord, ils sont en train de voler des petites choses et puis il va tomber. Et puis, madame ne fait pas attention. L'eau est en train de passer par terre dans la maison. Elle est en train de laver des affaires. Et puis la maison, c'est ouvert, je pense. C'est pas très bien dans cette maison. C'est une chose qui a trois au lieu de quatre. Ici, c'est ouvert, c'est pas mal. C'est une place où on ne fait pas attention, ni la mère ni les enfants. Ils font ce qu'ils veulent. C'est mal. Ici, là, il y a un trou aussi dans la maison. Il y a de l'eau qui est, mais ça va à travers un trou là, qui devrait pas être là. La dame ne regarde pas ses enfants.

L2

This is a young lady, lady who's doing her wash, washing. The water in the house is is going over and on the floor. There's a boy and a chair and he's falling. He's trying to get something, a jar. There's a young girl who's laughing. She seems to think there's gonna be a something that's going to happen that's going to be awfully funny. In the whole place, things are so badly taking place.

PD Patient

L1

Alors la maman, elle essuie la vaisselle. La fenêtre est entrouverte. On a l'impression qu'elle entend, qu'elle écoute, ou qu'elle est distraite par quelque chose, parce que l'eau du robinet a renversé sur le plancher. Elle prend pas connaissance non plus que les enfants sont en train de grimper sur un tabouret, qu'ils vont tomber, qu'ils vont se faire mal. Elle est vraiment distraite. Les enfants essaient d'attraper des biscuits dans un contenant à biscuits. En grimpant sur le tabouret, le garçon va tomber et la mère en est tout à fait inconsciente.

L2

I'm observing a mother, a woman, a mother who's doing dishes. She's looking outside. She seems totally absorbed by what she's seeing outside because she's not aware that her sink is overflowing with water. She's also not aware that the children behind her have climbed on the stool which is just about to tip over. They're trying to get cookies. She's totally focused on what's happening outside and ignores the dangers that lurk within her own home.

Appendix H:
PTG Sentences

Part 1: Practice Trials

1. Often, I justify my expenses. To get reimbursed, yesterday I __________ my expenses. (R)
2. Often, I shrink pants. Because I am not always careful, yesterday I __________ pants. (I)
3. Sometimes, I swir the pictures in the album. Like I sometimes do, yesterday I __________ the pictures in the album. (P)
4. Every year, I partake in the marathon. At the mountain tomorrow, I will be __________ in the marathon. (F)
5. Every day, I pleave the clothes in the dryer. After washing them yesterday, I __________ the clothes in the dryer. (P)
6. Every day, I cook carrots. Because they taste good, yesterday I __________ carrots. (R)
7. Every day, I prass the socks in the drawer. Like every day, tomorrow I will be __________ the socks in the drawer. (F)
8. Sometimes, I withdraw my name from a volunteer list. To get a break, yesterday I __________ my name from a volunteer list. (I)
9. Every day, I swick my books to school. For my classes tomorrow, I will be __________ my books to school. (P)
10. Every day, I cope with back pain. Because I have to, tomorrow I will be __________ with back pain. (F)
11. Every day, I overhear the neighbors arguing. Like every day, tomorrow I will be __________ the neighbors arguing. (F)

Part 1: Experimental Trials

1. Every day, I glaze cakes at the bakery. To decorate them, yesterday I __________ cakes at the bakery. (R)
2. Every day, I nibble on licorice. Because I love candy, yesterday I __________ on licorice. (R)
3. Every day, I splawl him an orange. As I do every day, yesterday I __________ him an orange. (P)
4. Every spring, I breed plants. Given that spring is here, yesterday I __________ plants. (I)
5. Often, I look in the newspaper. To find a new job, yesterday I __________ in the newspaper. (R)
6. Every day, I classify files. To keep them in order, tomorrow I will be __________ files. (F)
7. Sometimes, I crog a story to my daughter. Before I put her to bed yesterday, I __________ a story to my daughter. (P)
8. Often, I stray from the courtyard. Because I am adventurous, yesterday I __________ from the courtyard. (R)
9. Often, I reach for my daughter's hand. To cross the street, yesterday I __________ for my daughter's hand. (R)
10. Often, I meet a friend for lunch. At the restaurant yesterday, I __________ a friend for lunch. (I)
11. Often, I nop in the sun on the beach. Due to the nice weather, yesterday I __________ in the sun on the beach. (P)

12. Sometimes, I whip the eggs. To make a soufflé, yesterday I __________ the eggs. (R)

13. Every day, I undo my tie after work. On my way home tomorrow, I will be __________ my tie. (F)

14. Sometimes, I bleed when I floss. Because my gums are sensitive, yesterday I __________ when I flossed. (I)

15. Often, I fail an exam. Because of the difficulty, yesterday I __________ an exam. (R)

16. Sometimes, I strite a drink with friends. At the bar yesterday, I __________ a drink with friends. (P)

17. Often, I fire my gun to scare away the wolves. Out of fear, yesterday I __________ my gun to scare away the wolves. (R)

18. Every day, I splan at the restaurant. For lunch yesterday, I __________ at the restaurant. (P)

19. Every day, I adjust the volume on the radio. To make it louder, yesterday I __________ the volume on the radio. (R)

20. Every day, I bend iron at the shop. As part of my work, yesterday I __________ iron at the shop. (I)

21. Sometimes, I clur the radio in the car. To hear the news tomorrow, I will be __________ the radio in the car. (F)

22. Sometimes, I mork the papers on my desk. To organize myself, yesterday I __________ the papers on my desk. (P)

23. Sometimes, I gain an advantage over my opponent. At the game yesterday, I __________ an advantage over my opponent. (R)

24. Sometimes, I ring doorbells in the area. To sell door-to-door, yesterday I __________ doorbells in the area. (I)

25. Often, I dar a lottery ticket. To win the jackpot, tomorrow I will be __________ a lottery ticket. (F)

26. Often, I sway the committee to see my point. At the meeting yesterday, I __________ the committee to see my point. (R)

27. Sometimes, I gleck a beat on my drum. On my drum yesterday I __________ a drum. (P)

28. Sometimes I stride across a puddle. Due to the rain, yesterday I __________ across a puddle. (I)

29. Often, I win a game of chess. Because of my skill, yesterday I __________ a game of chess. (I)

30. Every day, I staw over the oven. To cook dinner, yesterday I __________ over the oven. (P)

31. Sometimes, I memorize a list. So as not to forget, tomorrow I will be __________ a list. (F)

32. Often, I cray late to work. Like I often do, yesterday I __________ late to work. (P)

33. Sometimes, I sing a song of love. Because I am in love, yesterday I __________ a song of love. (I)

34. Every day, I dreck the clothes out to dry. After washing them yesterday, I __________ the clothes out to dry. (P)

35. Often, I pour myself a glass of lemonade. To quench my thirst yesterday, I __________ myself a glass of lemonade. (R)

36. Every day, I deal the cards at the casino. As part of my work, yesterday I __________ the cards at the casino. (I)

37. Every day, I wring the wet rags. Before hanging them to dry, yesterday I __________ the wet rags. (I)

38. Often, I shraw my sunglasses in the sun. To protect my eyes, yesterday I __________ my sunglasses in the sun. (P)

39. Often, I donate food. To help feed the poor, tomorrrow I will be __________ food. (F)

40. Often, I drive my son to school. As I often do, yesterday I __________ my son to school. (I)

41. Every day, I play the violin. At the concert yesterday I __________ the violin. (R)

42. Every day, I owe an explanation to my boss. Like every day, yesterday I __________ an explanation to my boss. (R)

43. Sometimes, I teach a history class. At the local university, yesterday I __________ a history class. (I)

44. Often, I glue pieces of wood together. With my glue gun, yesterday I __________ pieces of wood together. (R)

45. Every day, I string beads. To make a bead necklace, yesterday I __________ beads. (I)

46. Every day, I clore the messages for the boss. As part of my work, yesterday I __________ the messages for the boss. (P)

47. Sometimes, I take him to work with me. In fact, yesterday I __________ him to work with me. (I)

48. Every day, I wet the counter when I do the dishes. After dinner tomorrow, I will be __________ the counter when I do the dishes. (F)

49. Every day, I beg my son to come home. Because I miss him, yesterday I __________ my son to come home. (R)

50. Every day, I buy coffee at the bistro. At the bistro yesterday I __________ coffee. (I)

51. Every day, I bind books at work. As part of my work, yesterday I __________ books. (I)

52. Sometimes I bet on horses. At the racetrack tomorrow, I will be __________ on horses. (F)

<u>Part 2: Practice Trials</u>

1. Often, I hire new workers. As the manager, yesterday I __________ new workers. (R)
2. Every day, I lail my teeth before bed. Before bed tomorrow, I will be __________ my teeth. (F)
3. Often, I mislead opponents. To protect members of my party, yesterday I __________ opponents. (I)

4. Sometimes, I spoof my hair in the shower. In the shower yesterday I __________ my hair. (P)

5. Sometimes, I slide down the snow-covered hills. With my toboggan, yesterday I __________ down the snow-covered hill. (I)

Part 2: Experimental Trials

53. Every day, I zye a nap when I get home. After work yesterday, I __________ a nap when I got home. (P)

54. Sometimes, I cling to his arm when I am scared. During the horror movie, yesterday I __________ to his arm. (I)

55. Often, I prap around the lake in my boat. To go fishing, yesterday I __________ around the lake in my boat. (P)

56. Every day, I pull the laces to untie my shoes. To take them off, yesterday I __________ the laces to untie my shoes. (R)

57. Sometimes, I roll marbles on the floor. To play with the children, yesterday I __________ marbles on the floor. (R)

58. Every day, I deposit money in the bank. To avoid spending it, tomorrow I will be __________ money in the bank. (F)

59. Every day, I fan myself to keep cool. Due to the heat, yesterday I __________ myself to keep cool. (R)

60. Often, I lore the books on the shelves. At the library, yesterday I __________ the books on the shelves. (P)

61. Every day, I brole beans for dinner. With the chicken yesterday, I __________ beans for dinner. (P)

62. Sometimes, I loose money at poker. Because of bad luck, yesterday I __________ money at poker. (I)

63. Every day, I mafe customers at the store. At the store, tomorrow I will be __________ customers. (F)

64. Sometimes, I cry at sad movies. Like I sometimes do, yesterday I __________ at a sad movie. (R)

65. Often, I slip on the ice at the arena. At the hockey game yesterday, I __________ on the ice. (R)

66. Every day, I proy my love for him. Because I love him, yesterday I __________ my love for him. (P)

67. Every day, I hold our baby in my arms. Because I love him, yesterday I __________ our baby in my arms. (I)

68. Every day, I forbid my children to speak to strangers. To keep them safe, yesterday I __________ my children to speak to strangers. (I)

69. Sometimes, I nace bubbles in the bathtub. For my son's bath, yesterday I __________ bubbles in the bathtub. (P)

70. Often, I raise money for charity. At the benefit concert, yesterday I __________ money for charity. (R)

71. Often, I shed light on the problems at work. At the meeting tomorrow, I will be __________ light on the problems at work. (F)

72. Sometimes, I gorn a glass of red wine. With dinner yesterday, I __________ a glass of red wine. (P)

73. Often, I freeze vegetables from the garden. To avoid waste, yesterday I __________ vegetables from the garden. (I)

74. Every day, I ploon my ideas to the boss. At the meeting, yesterday I __________ my ideas to the boss. (P)

75. Often, I weep out of happiness. Because of my happiness, yesterday I __________ out of happiness. (I)

76. Sometimes, I break the zipper on my pants. Because they are too tight, yesterday I __________ the zipper on my pants. (I)

77. Sometimes, I pass the ball to him. At the soccer game yesterday, I __________ the ball to him. (R)

78. Sometimes, I broy a sweater from my friend. From my friend, yesterday I __________ a sweater. (P)

79. Sometimes, I scan through novels. At the bookstore yesterday, I __________ through novels. (R)

80. Every week, I pluck my eyebrows. To keep them from growing too wide, tomorrow I will be __________ my eyebrows. (F)

81. Often, I cure an infection. Using antibiotics, yesterday I __________ an infection. (R)

82. Sometimes, I nish the alarm to wake up. For work tomorrow, I will be __________ the alarm to wake up. (P)

83. Sometimes, I tunch my car in the garage. Because of the snow, yesterday I __________ my car in the garage. (P)

84. Every day, I plip the packages at work. As part of my work, yesterday I __________ the packages. (P)

85. Often, I die of heat. Because of the broken air conditioner, yesterday I __________ of heat. (R)

86. Often, I hoil the dishes in the dishwasher. To wash them, yesterday I __________ the dishes in the dishwasher. (P)

87. Sometimes, I withhold money from my paycheck. To save for my retirement, yesterday I __________ money from my paycheck. (I)

88. Every day, I sell flowers at our shop. To make a living, yesterday I __________ flowers at our shop. (I)

89. Often, I glip my car to work. For convenience, tomorrow I will be __________ my car to work. (F)

90. Sometimes, I plan a party. Because of her birthday, yesterday I __________ a party. (R)

91. Often, I glaw music in the car. On my way home yesterday, I __________ music in the car. (P)

92. Often, I foresee danger. Because I like to be safe, yesterday I __________ danger. (I)

93. Every day, I help her with her work. Like every day, yesterday I __________ her with her work. (R)

94. Every day, I chay a sound upstairs. Like every day, yesterday I __________ a sound upstairs. (P)

95. Every day, I eat green vegetables. To maintain a healthy diet, yesterday I __________ green vegetables. (I)

96. Sometimes, I strive to do my best. For the exam tomorrow, I will be __________ to do my best. (F)

97. Often, I feed the birds by the pond. Like I often do, yesterday I __________ the birds by the pond. (I)

98. Often, I catch the ball when it is passed to me. At the game yesterday, I __________ the ball when it was passed to me. (I)

99. Often, I wish upon a star. Due to the clear skies, last night I __________ upon a star. (R)

100. Often, I scur tea at noon. As I often do, yesterday I __________ tea at noon. (P)

101. Every day, I chat with the neighbour. Because she is friendly, tomorrow I will be __________ with the neighbour. (F)

102. Often, I view a movie. Because I like to, yesterday I __________ a movie. (R)

103. Often, I split logs to make firewood. To make firewood tomorrow, I will be __________ logs. (F)

104. Often, I swim at the city pool. To exercise, yesterday I __________ at the city pool. (I)

105. Every day, I stick labels on the packages. As part of my work, yesterday I __________ labels on the packages. (I)

106. Every day, I saze on my way home from work. Like every day, yesterday I __________ on my way home from work. (P)

107. Every day, I slan across the street. To get to the other side, yesterday I __________ across the street. (P)

108. Every day, I pray to god. Because I am a believer, yesterday I __________ to god. (R)

109. Sometimes, I ride the bus to work. To get to work yesterday, I __________ the bus. (I)

110. Sometimes, I cause them to laugh. Because of my jokes, yesterday I __________ them to laugh. (R)

111. Every day, I save money for my retirement. To plan my retirement, yesterday I __________ money for my retirement. (R)

112. Often, I tell my son a story before bed. Before I put him to bed yesterday, I __________ my son a story. (I)

<u>Part 3: Practice Trials</u>

1. Often, I listen to classical music. Because I like to, yesterday I __________ to classical music. (R)

2. Every day, I fold the laundry. After washing it, yesterday I __________ the laundry. (R)

3. Every day, I crave sweets. Because I have a sweet tooth, tomorrow I will be __________ sweets. (F)

4. Often, I creep through the traffic. As a taxi driver, yesterday I __________ through the traffic. (I)

5. Every day, I verk the door before I leave. On my way out yesterday, I __________ the door before I left. (P)

Part 3: Experimental Trials

113. Often, I slore carrots for a snack. In the afternoon yesterday, I __________ carrots for a snack. (P)

114. Every afternoon, I vie in competition. To make my wife proud, yesterday I __________ in competition. (R)

115. Every day, I vaw a deposit at the bank. At the bank tomorrow, I will be __________ a deposit. (F)

116. Often, I wape coffee in the morning. With breakfast yesterday, I __________ coffee. (P)

117. Often, I spy on my wife. Because I suspect she is cheating, yesterday I __________ on my wife. (R)

118. Every day, I weigh packages at work. As part of my work, yesterday I __________ packages. (R)

119. Often, I sleep on the couch in the afternoon. In order to rest, yesterday I __________ on the couch in the afternoon. (I)

120. Every day, I allocate time to practice yoga. Like every day, yesterday I __________ time to practice yoga. (R)

121. Sometimes, I run my business from home. All day yesterday, I __________ my business from home. (I)

122. Every evening, I re-think the events of the day. After dinner tomorrow, I will be __________ the events of the day. (F)

123. Sometimes, I stop at the store. On my way home yesterday, I __________ at the store. (R)

124. Sometimes, I rotch the pot with steel wool. To clean it, yesterday I __________ the pot with steel wool. (P)

125. Sometimes, I vask dinner with friends. At the restaurant yesterday I __________ dinner with friends. (P)

126. Every day, I work on the computer. At the office yesterday, I __________ on the computer. (R)

127. Often, I bleach the laundry. To get the clothes clean, tomorrow I will be __________ the laundry. (F)

128. Sometimes, I naze my dog around the block. For his walk yesterday, I __________ my dog around the block. (P)

129. Sometimes, I sting others with my sarcasm. Yesterday, I __________ others with my sarcasm. (I)

130. Every day, I drown out the noise from outside. Like every day, yesterday I __________ out the noise from outside. (R)

131. Every day, I froy in the bath after work. To relax, yesterday I __________ in the bath after work. (P)

132. Every day, I sweep the kitchen floor. To keep it clean, yesterday I __________ the kitchen floor. (I)

133. Sometimes, I lend my car to my son. Upon his request yesterday, I __________ my car to my son. (I)

134. Every day, I ploon my ideas to the boss. At the meeting yesterday, I __________ my ideas to the boss. (P)

135. Sometimes, I send him love letters. Because I love him, yesterday I __________ him love letters. (I)

136. Every week, I enclose checks with the payment stubs. To pay my employees, yesterday I __________ checks with the payment stub. (R)

137. Often, I fly a plane as a hobby. Due to the good weather, yesterday I __________ a plane as a hobby. (I)

138. Sometimes, I broy a sweater from my friend. From my friend, yesterday I __________ a sweater. (P)

139. Often, I sling my sac over my shoulder. To carry it yesterday, I __________ my sac over my shoulder. (I)

140. Every day, I choose a shirt to wear. In the morning yesterday, I __________ a shirt to wear. (I)

141. Often, I cure an infection. Using antibiotics, yesterday I __________ an infection. (R)

142. Sometimes, I nish the alarm to wake up. For work tomorrow, I will be __________ the alarm. (F)

143. Often, I plaw a dance of joy. To show my happiness, yesterday I __________ a dance of joy. (P)

144. Every day, I plip the packages at work. As part of my work, yesterday, I __________ the packages at work. (R)

145. Often, I copy figures from my sketchbook. Before class tomorrow, I will be __________ figures from my sketchbook. (F)

146. Sometimes, I use hand cream. To make my skin soft, yesterday I __________ hand cream. (R)

147. Sometimes, I write myself a note. To be sure not to forget, yesterday I __________ myself a note. (I)

148. Every day, I tie my son's shoelaces. As I do every day, yesterday I __________ my son's shoelaces. (R)

149. Every day, I dig holes for the city. As part of my work, yesterday I __________ holes for the city. (I)

150. Often, I move furniture around. To change the layout, yesterday I __________ furniture around. (R)

151. Every day, I keep my receipts. For my tax return, yesterday I __________ my receipts. (I)

152. Often, I bid on jewellery. To supply our jewellery store, yesterday I __________ on jewellery. (I)

153. Sometimes, I plar the day off. To go and play golf, yesterday I __________ the day off. (P)

154. Often, I chawl my children to the arena. For the hockey game yesterday, I __________ my children to the arena. (P)

155. Often, I shut the window before I leave. Because of the rain, tomorrow I will be __________ the window before I leave. (F)

156. Every day, I call my mother. To speak to her, yesterday I __________ my mother. (R)

157. Sometimes, I bring my lunch to work. To save money, yesterday I __________ my lunch to work. (I)

158. Every day, I speak to my mother. Over the telephone yesterday, I __________ to my mother. (I)

159. Every day, I enquire about my neighbour's wife. Because she is sick, yesterday I __________ about my neighbour's wife. (R)

160. Often, I forgive my mother in law. Because I love my husband, yesterday I __________ my mother in law. (I)

161. Sometimes, I step on the dog's tail. By accident, yesterday I __________ on the dog's tail. (R)

162. Often, I yawk the television when I am bored. Because of boredom, yesterday I __________ the television. (P)

Part 1 : Practice Trials

1. Tous les jours le concierge vide les poubelles. La cloche a sonné hier pendant que le concierge __________ les poubelles. (R)

2. Souvent, Michel acquiert des outils nouveaux. Michel a rencontré Lise hier pendant qu'il __________ des outils nouveaux. (I)

3. Souvent Isabelle allique ses cheveux. Isabelle a échappé son peigne hier pendant qu'elle __________ ses cheveux. (P)

4. Tous les jours Éric détient les prisonniers. Les autres gardes l'ont salué hier alors que nous __________ les prisonniers. (F)

5. Tous les jours, Robert plone une pomme. Le chat est entré hier pendant que Robert __________ une pomme. (P)

6. Souvent, Marie organise des sorties. Paul a appelé Marie hier pendant qu'elle __________ des sorties. (R)

7. Tous les jours, Suzanne pulque des épices. Le chat est entré hier pendant que nous __________ des épices. (F)

8. Souvent, Pierre obtient de l'argent. Pierre s'est fait volé hier alors qu'il __________ de l'argent. (I)

9. Tous les jours, Éric aruge ses trophées. Lise a salué Éric hier pendant qu'il __________ ses trophées. (P)

10. Souvent, Serge circule dans la voie de gauche. Serge a eu un accident hier pendant que nous __________dans la voie de gauche. (F)

11. Souvent, Aline intervient auprès du public. Le maire l'a saluée hier pendant que nous __________ auprès du public. (F)

Part 1 : Experimental Trials

1. Tous les jours, Sylvie cuisine des légumes. Les enfants sont arrivés hier pendant que Sylvie __________ des légumes. (R)

2. Tous les jours, Robert taille des habits. Un client est entré hier pendant que Robert __________des habits. (R)

3. Tous les lundis, Maude pocle avec sa fille. Maude s'est blessée hier pendant qu'elle __________ avec sa fille. (P)

4. Tous les jours, Régeanne moud du café. Régeanne s'est coupée hier alors qu'elle __________ du café. (I)

5. Souvent, Marc trouve une solution aux mots croisés. Nancy lisait hier pendant que Marc __________ une solution aux mots croisés. (R)

6. Souvent, Pierre vante les mérites de l'entreprise. Le patron est entré hier pendant que nous __________ les mérites de l'entreprise. (F)

7. Tous les jours, Annie croge ses cheveux. Jean a appelé Annie hier pendant qu'elle __________ ses cheveux. (P)

8. Tous les jours, Jacques transporte son équipement. Jacques s'est fait volé hier alors qu'il __________ son équipement. (R)

9. Maintenant qu'elle s'y est habituée, Louise aime son auto manuelle. Mais avant ça, elle __________ pas son auto manuelle. (R)

10. Souvent, Marie fait des emplettes. Marie s'est évanouie hier pendant qu'elle __________ des emplettes. (I)

11. Tous les jours, Ginette prade le chemin. Ginette a rencontré Paul hier pendant qu'elle __________ le chemin. (P)

12. Tous les matins, Sophie réveille les enfants. Jean préparait le déjeuner hier pendant que Sophie __________ les enfants. (R)

13. Souvent, Patricia interrompt les jeux. La cloche a sonné hier alors que nous __________ les jeux. (F)

14. Tous les soirs, Louise éteint la lumière. Il a tonné hier alors que Louise __________ la lumière. (I)

15. Tous les jours, Hélène porte un sac pesant. Hélène s'est faite une entorse hier pendant qu'elle __________ un sac pesant. (R)

16. Souvent, Nadia broine le plancher. Le téléphone a sonné hier pendant que Nadia __________ le plancher. (P)

17. Tous les matins, Louise planifie sa journée. Le téléphone a sonné hier pendant que Louise __________ sa journée. (R)

18. Souvent, Anne cuge du jus de fruits. Lise est arrivée hier pendant qu'Anne __________ du jus de fruits. (P)

19. Tous les jours Aline dépense de l'argent. Son mari travaillait fort hier pendant qu'Aline __________ de l'argent. (R)

20. Parfois, Robert parvient au haut de la montagne. Robert a eu le vertige hier alors qu'il __________ au haut de la montagne. (I)

21. Tous les jours, Marie sadre un livre. Le téléphone a sonné hier pendant que nous __________ un livre. (F)

22. Parfois, Julie plunaque sur la route. Julie a eu un accident hier pendant qu'elle __________ sur la route. (P)

23. Tous les matins, Louis mange des céréales. Julie a appelé Louis hier pendant qu'il __________ des céréales. (R)

24. Tous les jours, Sarah écrit une lettre. Le stylo s'est brisé hier pendant que Sarah __________ une lettre. (I)

25. Tous les jours, Diane relabre son plan. On a sonné à la porte hier pendant que nous __________ son plan. (F)

26. Souvent, la gardienne surveille les enfants. Les parents sont revenus hier pendant que la gardienne __________ les enfants. (R)

27. Souvent, Nathalie joffe un taxi. Roger a salué Nathalie hier pendant qu'elle __________ un taxi. (P)

28. Parfois, Pierre meurt d'ennui en classe. Lucie s'amusait en classe hier pendant que Pierre __________ d'ennui en classe. (I)

29. Tous les jours, Julie sert les clients du bistro. Pierre est entré hier pendant que Julie __________ les clients du bistro. (I)

30. Parfois, Alice durfe au téléphone. On a sonné à la porte hier pendant qu'Alice __________ au téléphone. (P)

31. À l'occasion, Simone dîne au restaurant. Pierre a salué Simone hier pendant que nous __________ au restaurant. (F)

32. Parfois, Jacques lordue un camion. Jacques a eu une contravention hier pendant qu'il __________ un camion. (P)

33. Tous les deux jours, Marc sort la poubelle. France a salué Marc hier pendant qu'il __________ la poubelle. (I)

34. Tous les jours, Arthur badure une revue. On a sonné à la porte hier pendant qu'Arthur __________ une revue. (P)

35. Tous les jours Paul discute avec sa femme. Un ami a appelé Paul hier pendant qu'il __________ avec sa femme. (R)

36. Tous les jours, Michel conçoit un nouveau projet. Un élève est entré hier pendant que Michel __________ un nouveau projet. (I)

37. Souvent, Rose coud des vêtements. Rose a perdu son aiguille hier pendant qu'elle __________ des vêtements. (I)

38. Tous les jours, Henri droile à l'ordinateur. Henri a eu mal aux yeux hier pendant qu'il __________ à l'ordinateur. (P)

39. Parfois, Louis accorde le piano. Le téléphone a sonné hier pendant que nous __________ le piano. (F)

40. Tous les jours, Jean met du lait dans son café. Jean a renversé sa tasse hier pendant qu'il __________ du lait dans son café. (I)

41. Tous les jours, Louise appelle Michel. La ligne s'est coupée hier pendant que Louise __________ Michel. (R)

42. Tous les jours, Lucie traverse le pont. L'accident est survenu hier pendant que Lucie __________ le pont. (R)

43. Tous les jours, Joseph reçoit du courrier. Rose a salué Joseph hier pendant qu'il __________ du courrier. (I)

44. Tous les jours, Louise étudie la biologie. Michel a appelé Louise hier pendant qu'elle __________ la biologie. (R)

45. Tous les jours, Paul cuit du pain. Paul s'est brûlé hier pendant qu'il __________ du pain. (I)

46. Tous les jours, Julie mifre un film. Le téléphone a sonné hier pendant que Julie __________ un film. (P)

47. Parfois, Luc dit des méchancetés. Anne a pleuré hier pendant que Luc __________ des méchancetés. (I)

48. Tous les jours, Julie apprend les mathématiques. Le professeur est entré hier pendant que nous __________ les mathématiques. (P)

49. Tous les matins Marc livre les journaux. Édith a salué Marc hier pendant qu'il __________ les journaux. (R)

50. Tous les jours, Bernard lit le journal. On a sonné à la porte hier pendant que Bernard __________ le journal. (I)

51. Souvent, Rachel peint un tableau. Le pinceau s'est brisé hier pendant que Rachel __________ un tableau. (I)

52. Tous les jours, Pierre suit le téléjournal. Le téléphone a sonné hier pendant que nous __________ le téléjournal. (F)

Part 2 : Practice Trials

1. Parfois, Roger arrête des voleurs. Roger s'est blessé hier alors qu'il __________ des voleurs. (R)
2. Souvent, Alfonse loufre l'auto. Annie a salué Alfonse hier pendant que nous __________ l'auto. (F)
3. Parfois, Carole suspend le linge mouillé dehors. Sa voisine l'a saluée hier pendant que Carole __________ le linge mouillé dehors. (I)
4. Parfois, Jean larte avec ses voisins. Jean s'est blessé à la cheville hier alors qu'il __________ avec ses voisins. (P)
5. Tous les matins, Luc reprend la route. La voiture est tombée en panne hier alors que Luc __________ la route. (I)

Part 2 : Experimental Trials

53. Tous les jours, Jeanne blique son sac à main. Jeanne s'est faite volé hier pendant qu'elle __________ son sac à main. (P)

54. Tous les jours, Nathalie boit du thé. Nathalie s'est étouffée hier pendant qu'elle __________ du thé. (I)

55. Parfois, Ève ploue les revues de mode. Pierre a salué Ève hier pendant qu'elle __________ les revues de mode. (P)

56. Tous les jours, Serge joue avec son fils. Le facteur est passé hier pendant que Serge __________ avec son fils. (R)

57. Tous les jours, Roger quitte la maison. Sa voisine l'a salué hier alors que Roger __________ la maison. (R)

58. Parfois, André interroge les témoins. André a reçu un appel hier pendant que nous __________ les témoins. (F)

59. Souvent, Paul décide quoi manger. Line choisissait un film hier pendant que Paul __________ quoi manger. (R)

60. Tous les jours, Émilie berde le journal. On a sonné à la porte hier pendant qu'Émilie __________ le journal. (P)

61. Tous les jours, Marie tibe en classe. Le directeur est entré hier pendant que Marie __________ en classe. (P)

62. Tous les soirs, Luc revient du travail. Luc a eu une contravention hier pendant qu'il __________ du travail. (I)

63. Parfois, Suzanne lige ses souliers. Émile est entré hier pendant que nous __________ ses souliers. (F)

64. Tous les soirs, Bernard raconte une histoire. Son fils s'est endormi hier pendant que Bernard __________ une histoire. (R)

65. Tous les jours, Luc accompagne Marie à son travail. Line a rencontré Luc hier alors qu'il __________ Marie à son travail. (R)

66. Tous les jours, Stéphane sorle ses pantalons. Le téléphone a sonné hier pendant que Stéphane __________ ses pantalons. (P)

67. Souvent, Annie tient son bébé sur elle. Le biberon est tombé hier pendant qu'Annie __________ son bébé sur elle. (I)

68. Tous les jours, Jean teint les cheveux de ses clientes. Lianne est entrée hier pendant que Jean __________ les cheveux de ses clientes. (I)

69. Tous les jours, Michel redaube son auto. Michel est tombé en panne hier pendant qu'il __________ son auto. (P)

70. Tous les jours, Jean écoute de la musique. Il y a eu une panne de courant hier pendant que Jean __________ de la musique. (R)

71. Tous les jours, René entreprend une tâche nouvelle. Le patron est entré hier pendant que nous __________ une tâche nouvelle. (F)

72. Souvent, Rose muque un gâteau. Il y a eu une panne de courant hier pendant que Rose __________ un gâteau. (P)

73. Souvent, le médecin prescrit des médicaments. Alice est entrée hier pendant que le médecin __________ des médicaments. (I)

74. Souvent, Sandra danse la salsa. Paul a pris une photo de Sandra hier pendant qu'elle __________ la salsa. (R)

75. Tous les jours, Jeannine étend le linge dehors. Pierre a salué Jeannine hier pendant qu'elle __________ le linge dehors. (I)

76. Tous les jours, Pierre prend des médicaments. Le téléphone a sonné hier pendant que Pierre __________ des médicaments. (I)

77. Tous les jours, Jeanne passe l'aspirateur. On a sonné à la porte hier pendant que Jeanne __________ l'aspirateur. (R)

78. Toutes les semaines, Denise cloque ses plantes. On a sonné à la porte hier pendant que Denise __________ ses plantes. (P)

79. Tous les matins, Jean promène son chien. Jean a rencontré son voisin hier pendant qu'il __________ son chien. (R)

80. Parfois, Nadine accroche un cadre au mur. On a sonné à la porte hier pendant que nous __________ un cadre au mur. (F)

81. Tous les matins, Paul monte à bord de l'autobus. Annie a salué Paul hier alors qu'il __________ à bord de l'autobus. (R)

82. Tous les jours, Nancy répond aux clients. Le patron est entré hier pendant que Nancy __________ aux clients. (I)

83. Tous les soirs, Céline drâle de sommeil. Le bébé s'est mis à pleurer hier alors que Céline __________ de sommeil. (P)

84. Souvent, Hélène codume dans la rue. Il a commencé à pleuvoir hier alors qu'Hélène __________ dans la rue. (P)

85. Souvent, Nadia commence un nouveau livre. Sa cousine a appelé hier alors que Nadia __________ un nouveau livre. (R)

86. Parfois, Émilie dorde une tarte. Le fourneau s'est brisé hier pendant qu'Émilie __________ une tarte. (P)

87. Aujourd'hui encore, il pleut fort. Rollande a ouvert son parapluie en sortant hier parce qu'il __________ fort. (I)

88. Parfois, Élise craint la foudre. Il pleuvait fort hier pendant qu'Élise __________ la foudre. (I)

89. Parfois, Aline dabre des ananas. Il y a eu une panne de courant hier pendant que nous __________ des ananas. (F)

90. Tous les matins, Annik prépare son lunch. Arthur est parti hier matin pendant qu'Annik __________ son lunch. (R)

91. Parfois, Line muise un parapluie. Il s'est mis à pleuvoir hier pendant que Line __________ un parapluie. (P)

92. Tous les soirs, Marie endort son bébé. On a sonné à la porte hier pendant que Marie __________ son bébé. (I)

93. Tous les soirs, Louise entre dans la maison. Le téléphone a sonné hier pendant que Louise __________ dans la maison. (R)

94. Parfois, Karine lope au restaurant. Karine s'est étouffée hier alors qu'elle __________ au restaurant. (P)

95. Souvent, Bernard se plaint d'avoir mal au dos. Jean a interrompu Bernard hier pendant qu'il se __________ d'avoir mal au dos. (I)

96. Tous les jours, Line défend un accusé. Le témoin s'est évanoui hier pendant que nous __________ un accusé. (F)

97. Tous les matins, Roger part pour le travail. Sa voisine l'a salué hier alors que Roger __________ pour le travail. (I)

98. Tous les jours, Lucie rend la monnaie aux clients. Lucie s'est faite volée hier alors qu'elle __________ la monnaie aux clients. (I)

99. Souvent, Bernard cherche ses clés. Bernard a retrouvé ses gants hier pendant qu'il __________ ses clés. (R)

100. Souvent, Rita baffe d'ennui. Richard a appelé Rita hier pendant qu'elle __________ d'ennui. (P)

101. Parfois, Raymond célèbre une victoire. Jeanne a porté un toast hier pendant que nous __________ une victoire. (F)

102. Souvent, Karine repasse des vêtements. Il y a eu une panne de courant hier pendant que Karine __________ des vêtements. (R)

103. Souvent, Luc convient à rencontrer un candidat. Anne est entrée hier pendant que nous __________ à rencontrer un candidat. (F)

104. Souvent, Isabelle vend des bijoux. Les voleurs sont entrés hier pendant

qu'Isabelle __________ des bijoux. (I)

105. Tous les jours, Diane conduit sur l'autoroute. L'accident est arrivé hier pendant que Diane __________ sur l'autoroute. (I)

106. Parfois, Roger défogile vers la montagne. Roger a vu un ours hier alors qu'il __________ vers la montagne. (P)

107. Tous les jours, Paul puille des tulipes. Il a fait soleil hier pendant que Paul __________ des tulipes. (P)

108. Souvent, Jeanne change les couches du bébé. Le téléphone a sonné hier pendant que Jeanne __________ les couches du bébé. (R)

109. Toujours, Rose comprend son retard. Michel s'excusait profusément hier alors que Rose __________ son retard. (I)

110. Tous les soirs, Émilie chante une chanson. Son père jouait du piano hier pendant qu'Émilie __________ une chanson. (R)

111. Souvent, Paul propose une activité au groupe. La cloche a sonné hier pendant que Paul __________ une activité au groupe. (R)

112. Souvent, Carole doit de l'argent. Carole a acheté d'autres choses hier alors qu'elle __________ de l'argent. (I)

Part 3 : Practice Trials

1. Tous les jours, Simone adresse une lettre. Le stylo s'est brisé hier alors que Simone __________ une lettre. (R)

2. Souvent, Paul ajoute du poivre à la soupe. On a sonné à la porte hier pendant que Paul __________ du poivre à la soupe. (R)

3. Souvent, Jean commande une pizza. Les voisins sont venus hier pendant que nous __________ une pizza. (F)

4. Souvent, Rose fuit les journalistes. Rose a eu un accident hier alors qu'elle __________ les journalistes. (I)

5. Souvent, Aline fuide dans le salon. Éric est entré hier pendant qu'Aline __________ dans le salon. (P)

Part 3 : Experimental Trials

113. Souvent, Joseph noque sur le fauteuil. Simone est entrée hier pendant que Joseph __________ sur le fauteuil. (P)

114. Souvent, Simone tricote des pantoufles. On a sonné à la porte hier pendant que Simone __________ des pantoufles. (R)

115. Parfois, Jean nocre les oiseaux. Il a commencé à pleuvoir hier pendant que nous __________ les oiseaux. (F)

116. À l'occasion, Louise lorque sous l'arbre. Michel a rencontré Louise hier alors qu'elle __________ sous l'arbre. (P)

117. Souvent, Marie bavarde avec sa voisine. Il s'est mis à pleuvoir hier pendant que Marie __________ avec sa voisine. (R)

118. Tous les jours, Pierre avance la voiture. L'accident est survenu hier pendant que Pierre __________ la voiture. (R)

119. Parfois, Maryse aperçoit un arc-en-ciel. Son chapeau s'est envolé hier alors que Maryse __________ un arc-en-ciel. (I)

120. Souvent, Annie dessine une maison. La maîtresse a regardé Annie hier pendant qu'elle __________ une maison. (R)

121. Souvent, Anne sait la réponse aux devinettes. Anne a gardé le silence hier alors qu'elle __________ la réponse aux devinettes. (I)

122. Toutes les semaines, Robert tond le gazon. Il a commencé à pleuvoir hier pendant que nous __________ le gazon. (F)

123. Tous les soirs, Jean regarde la télévision. Marie est entrée hier soir pendant que Jean __________ la télévision. (R)

124. Tous les jours, Johanne ranse les escaliers. Johanne s'est blessée hier alors qu'elle __________ les escaliers. (P)

125. Souvent, Daniel sirde une arme à feu. Daniel s'est blessé hier pendant qu'il __________ une arme à feu. (P)

126. Parfois, Luc demande des renseignements. Une jeune fille a abordé Luc hier pendant qu'il __________ des renseignements. (R)

127. Tous les jours, Julie continue le projet. Le patron est venu hier alors que nous __________ le projet. (F)

128. Tous les jours, Paul daloge sa bicyclette. Il s'est mis à pleuvoir hier pendant que Paul __________ sa bicyclette. (P)

129. Souvent, le chimiste dissout des solvants. Le feu a pris hier pendant que le chimiste __________ des solvants. (I)

130. Souvent, Lise caresse son chat. Le chien s'est mis a japper hier pendant que Lise __________ son chat. (R)

131. Parfois, Joseph dourde un livre. Hélène a salué Joseph hier alors qu'il __________ un livre. (P)

132. Souvent, Gilles poursuit des voleurs. Du renfort est arrivé hier pendant que Gilles __________ des voleurs. (I)

133. Tous les soirs, Anne rejoint sa mère au téléphone. La ligne a été coupée hier alors qu'Anne __________ sa mère au téléphone. (I)

134. Tous les jours, Maurice vurque des réparations. Maurice s'est blessé hier pendant qu'il __________ des réparations. (P)

135. Cette semaine Diane devient directrice. Diane a rencontré les professeurs hier alors qu'elle __________ directrice. (I)

136. Tous les matins, Julie se brosse les cheveux. Julie a échappé sa brosse hier alors qu'elle se __________ les cheveux. (R)

137. Souvent, Annie dort dans le salon. Pierre est revenu hier pendant qu'Annie __________ dans le salon. (I)

138. Souvent, Roger juffle en avion. Il y a eu de la turbulence hier pendant que Roger __________ en avion. (P)

139. Tous les jours, Marie transcrit ses notes. Son stylo s'est brisé hier pendant que Marie __________ ses notes. (I)

140. Souvent, Daniel descend les marches vite. Daniel est tombé hier pendant qu'il __________ les marches vite. (I)

141. Tous les jours, Simone lave son linge. Paul a appelé Simone hier pendant qu'elle __________ son linge. (R)

142. Parfois, Suzanne lige ses souliers. Émile est entré hier pendant que nous __________ ses souliers. (F)

143. Tous les lundis, André suque à la maison. Johanne est arrivée hier pendant qu'André __________ à la maison. (P)

144. Souvent, Aline reste au bord de la piscine. Les enfants se baignaient hier alors qu'Aline __________ au bord de la piscine. (R)

145. Parfois, Éloise admire le coucher du soleil. Il s'est mis à pleuvoir hier alors que nous __________ le coucher du soleil. (F)

146. Souvent, Mario parle au téléphone. On a sonné à la porte hier pendant que Mario __________ au téléphone. (R)

147. Rarement, Philippe vient ici. Philippe s'est perdu hier alors qu'il __________ ici. (I)

148. Tous les jours, Paul travaille à l'ordinateur. Ses yeux se sont mis à brûler hier pendant qu'il __________ à l'ordinateur. (R)

149. Souvent, Simone résout des mots croisés. Le stylo s'est brisé hier pendant que Simone __________ des mots croisés. (I)

150. Tous les matins, Annie donne du pain aux oiseaux. Il s'est mis à pleuvoir hier pendant qu'Annie __________ du pain aux oiseaux. (R)

151. Parfois, Simone sent les roses. Le fleuriste a aperçu Simone hier pendant qu'elle __________ les roses. (I)

152. Souvent, Line bout de l'eau. Roger est allé chercher les tasses hier pendant que Line __________ de l'eau. (I)

153. Tous les jours, Thérèse buisse le balai. Thérèse est tombée hier alors qu'elle __________ le balai. (P)

154. Tous les jours, Diane churte son agenda. Un élève est entré hier pendant que Diane __________ son agenda. (P)

155. Tous les jours, Michel entretient les fleurs. Le vent soufflait très fort hier pendant que nous __________ les fleurs. (F)

156. Tous les jours, Line pense à Paul. Par coïncidence, Paul a téléphoné hier alors que Line __________ à Paul. (R)

157. Souvent, Thérèse veut du repos. Thérèse a été obligée de travailler hier alors qu'elle __________ du repos. (I)

158. Souvent, Marc attend Line à la sortie. Marc a rencontré Isabelle hier alors qu'il __________ Line à la sortie. (I)

159. Tous les soirs, Anne corrige les devoirs de sa fille. Son mari est revenu hier pendant qu'Anne __________ les devoirs de sa fille. (R)

160. Souvent, l'accusé ment. Le détecteur de mensonges a sonné hier pendant que l'accusé __________. (I)

161. Souvent, Richard marche en forêt. Richard a aperçu un ours hier alors qu'il __________ en forêt. (R)

162. Parfois, Vincent roude au souper. Vincent s'est fait mal hier pendant qu'il __________ au souper. (P)