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Bilingual language intrusions and other speech errors in Alzheimer's disease

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ABSTRACT

The current study investigated how Alzheimer's disease (AD) affects production of speech errors in reading-aloud. Twelve Spanish-English bilinguals with AD and 19 matched controls read-aloud 8 paragraphs in four conditions (a) English-only, (b) Spanish-only, (c) English-mixed (mostly English with 6 Spanish words), and (d) Spanish-mixed (mostly Spanish with 6 English words). Reading elicited *language intrusions* (e.g., saying *la* instead of *the*), and several types of *within-language* errors (e.g., saying *their* instead of *the*). Patients produced more intrusions (and self-corrected less often) than controls, particularly when reading non-dominant language paragraphs with switches into the dominant language. Patients also produced more within-language errors than controls, but differences between groups for these were not consistently larger with dominant versus non-dominant language targets. These results illustrate the potential utility of speech errors for diagnosis of AD, suggest a variety of linguistic and executive control impairments in AD, and reveal multiple cognitive mechanisms needed to mix languages fluently. The observed pattern of deficits, and unique sensitivity of intrusions to AD in bilinguals, suggests intact ability to select a default language with contextual support, to rapidly translate and switch languages in production of connected speech, but impaired ability to monitor language membership while regulating inhibitory control.

1. Introduction

Although there is unanimous agreement that Alzheimer's disease (AD) results in language impairment, there is some debate as to which aspects of linguistic functioning are impaired in early stages of the disease and the underlying cognitive mechanism(s). By some accounts, linguistic impairments in AD primarily reflect damage to semantic representations (Adlam et al., 2006; Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Hodges & Patterson, 1995; Hodges, Salmon, & Butters, 1992) leading to the production of semantic errors, and leaving morphosyntactic aspects of speech relatively intact (here the assumption is that grammatical encoding is relatively modular and automatic; e.g., Kavé & Levy, 2003; Kempler, Curtiss, & Jackson, 1987). Others have suggested that AD results in broader linguistic impairments even in early stages of the disease (e.g., Altmann, Kempler, & Andersen, 2001; Croot, Hodges, Xuereb, & Patterson, 2000), possibly reflecting a primary deficit in working memory (e.g., Almor, Kempler, MacDonald, Andersen, & Tyler, 1999). Still others suggest that semantic errors predominate initially, but the production of morphosyntactic and phonological errors increases with disease progression (e.g., Murdoch, Chenery, Wilks, & Boyle, 1987), a pattern that fits with the propensity of the disease to first affect regions of temporal and parietal cortex followed by progression to cortical regions in the frontal lobes (Forbes-McKay, Shanks, & Venneri, 2013).

A consideration when studying language impairment in AD is that different types of tasks may be better suited than others for revealing specific aspects of linguistic impairment. For example, picture description reveals semantic impairments (as in Kavé & Levy, 2003), but free speech produced during a semi-structured interview may be better suited for exposing morphosyntactic processing deficits (Sajjadi, Patterson, Tomek, & Nestor, 2012). Although a large number of studies have attempted to characterize linguistic impairments in AD, relatively few have considered if and how speech errors might be elicited as a possible diagnostic tool.

In the present study we considered the possible effects of AD on production of bilingual speech errors in a read aloud task. Although reading comprehension is impaired in AD (e.g., Bayles, Tomoeda, & Trosset, 1992; Cummings, Houlihan, & Hill, 1986), reading aloud is a relatively spared skill. Some have argued that reading aloud is one of the skills most resistant to AD, remaining intact even in more advanced stages of disease progression (Cummings et al., 1986; Friedman, Ferguson, Robinson, & Sunderland, 1992; Sasanuma, Sakuma, & Kitano, 1992; but see Glosser & Grossman, 2004). Indeed, it is only at moderate stages of cognitive impairment that patients may

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exhibit increased difficulty with reading low-frequency words with irregular spelling-to-sound correspondences (e.g., *caste, cough, or sew* relative to matched regular words such as *carve, couch, and sag*; Strain, Patterson, Graham, & Hodges, 1998). Few studies have examined reading aloud in AD beyond the single word level (e.g., Chan, Salmon, & DeLaPena, 1999; Monti, Gabrieli, Wilson, & Reminger, 1994; Monti et al., 1997) and none of these have systematically examined production of speech errors during reading aloud though these could reveal the nature of linguistic impairments in AD and the cognitive mechanisms of the speech production system (Fromkin, 1971; Garrett, 1975, 1982).

In recent work we used a paragraph reading task (Kolers, 1966) to demonstrate that reading aloud elicits connected speech in a manner that engages the language production system and leads speakers to produce speech errors that resemble errors produced in spontaneous conversation (Gollan & Goldrick, 2016, in press; Gollan, Schotter, Gomez, Murillo, & Rayner, 2014). For example, bilinguals produced significantly more errors when reading aloud in their non-dominant language than when reading in their dominant language (e.g., producing *kept* instead of *keep*, or *turn* instead of *turning*). In addition, bilinguals reading aloud mixed-language paragraphs sometimes produced *intrusion errors* in which they spontaneously produced translations of written target words in their speech (e.g., saying *pero* instead of *but*). Aging bilinguals produced more intrusions than proficiency-matched young bilinguals in both the read aloud task (Gollan & Goldrick, 2016) and in verbal fluency tasks (Gollan, Sandoval, & Salmon, 2011). Additionally, bilinguals with AD produced more intrusion errors with disease progression in both picture-naming and word translation (Costa et al., 2012). However, it is not known if bilinguals with AD produce more intrusion errors than cognitively healthy bilingual matched controls.

In previous work we reported a counterintuitive pattern of linguistic impairment in which picture-naming deficits in bilinguals with AD were more robust in the dominant language than in the non-dominant language (Gollan, Salmon, Montoya, & Da Pena, 2010). This pattern was apparent in the initial stages of disease progression in bilinguals who had one clearly more proficient language (Ivanova, Salmon, & Gollan, 2014; Kowoll, Degen, Gladis, & Schröder, 2015), whereas balanced bilinguals exhibited parallel decline of both languages (Costa et al., 2012; Salvatierra, Rosselli, Acevedo, & Duara, 2007). This finding was counterintuitive because naming deficits are usually more pronounced for low-frequency than high-frequency words (Hodges et al., 1992; Kirshner, Webb, & Kelly, 1984; Ober & Shenaut, 1988; Thompson-Schill, Gabrieli, & Fleischman, 1999) and bilinguals generally speak their non-dominant language less frequently than their dominant language. Furthermore, anecdotal evidence and caregiver reports suggest that bilinguals with AD increasingly avoid the non-dominant language as dementia progresses (e.g., Mendez, Perryman, Pontón, & Cummings, 1999). Thus, the frequency effect in naming should favor the dominant language. Greater impairment in the dominant language would also be unexpected assuming deficits in executive control in AD (Baudic et al., 2006; Lafleche & Albert, 1995; Perry & Hodges, 1999); on this view, production of the non-dominant language should be more difficult because it requires bilinguals to control interference from the more accessible dominant language (Green, 1998; Meuter & Allport, 1999).

To explain the counterintuitive pattern, we initially suggested that dominant language representations might be more richly represented at the semantic level than non-dominant language representations and, therefore, more sensitive to subtle changes in the integrity of semantic representations at an early stage of disease (Gollan et al., 2010). In subsequent work, however, we found that the dominant language declines more rapidly than the non-dominant language in later stages of disease. To accommodate this finding we relied on the proposal that language impairments in AD may reflect deficits in effortful retrieval (Balota, Watson, Duchek, & Ferraro, 1999; McGlinchey-Berroth & Milberg, 1993; Nebes, Martin, & Horn, 1984; Ober, Shenaut, & Reed, 1995). Retrieval of words in the non-dominant language might generally be more effortful than retrieval of words in the dominant language. However, it is most difficult to retrieve very low frequency words, and the lowest-frequency/most difficult words bilinguals know most likely belong to their dominant language. Thus, if patients with AD have a deficit in effortful retrieval it may be most apparent compared to controls for these low frequency words that are only known in the dominant language. Neither patients nor controls are likely to know very low frequency words in the non-dominant language, so the retrieval deficit will initially not be as apparent in the non-dominant language (Ivanova et al., 2014). From this viewpoint, any task that elicits production of very low frequency words should expose greater differences between patients and controls in the dominant than in the non-dominant language. Relatively easier tasks (i.e., those with less effortful retrieval demands) should reveal the opposite pattern.

In our previous studies with the read aloud task, within-language errors (e.g., function word substitutions, omission errors, inflection errors) elicited the expected pattern of more errors in the non-dominant than the dominant language. Thus, on a difficulty based account, within-language errors in the non-dominant language should be more sensitive to AD than within-language errors in the dominant language. This prediction assumes that the read aloud task circumvents the problem we hypothesized might arise in picture naming; i.e., that the most difficult known words belong to the dominant language. This assumption is justified because the paragraphs selected for the present study generally contained relatively simple language and were not designed to elicit production of very difficult (i.e., low frequency) words. In contrast, targets in picture naming tests become progressively more difficult (i.e., lower frequency) as the test proceeds. In addition, when reading aloud full paragraphs, language production is aided by semantic context and grammatical encoding that is not available in picture-naming tests. We also sought to determine if different error subtypes among within-language errors might be differentially sensitive to AD. A previous study, for example, showed that the summed duration of all hesitations produced in a 4 min sample of spontaneous speech distinguished patients with AD from controls, whereas speech rate (phonemes per second) and grammatical errors (in syntax, or inflectional or derivational morphology) did not (Hoffmann et al., 2010).

Different predictions however, would follow for intrusion errors, which produced significantly *reversed-dominance effects* in previous studies such that bilinguals replaced dominant-language targets with non-dominant-language translations more often than the reverse (i.e., more often than they replaced non-dominant-language targets with dominant-language translations; Gollan & Goldrick, 2016, in press; Gollan et al., 2014). For example, an English-dominant bilingual would be more likely to replace the English word *reason* with its Spanish equivalent, *razón*, when reading aloud a sentence written mostly in Spanish (e.g., *Es por esa reason que digo que la leyenda de La Llorona es verdad*) than he would be to replace the Spanish *razón* with *reason*, when reading the English equivalent sentence (i.e., *It is because of that razón that I say that the legend of the Weeping Woman is true*). Moreover, reversed-dominance effects though slightly smaller, were not significantly smaller in older than in young bilinguals, and neither young nor older bilinguals exhibited more intrusions in the non-dominant than the dominant language (Gollan & Goldrick, 2016).

Importantly, reversed dominance effects have also been observed in young cognitively healthy bilinguals who named pictures more quickly in their nondominant than their dominant language when tested in mixed language blocks (e.g., Christoffels, Firk, & Schiller, 2007; Costa & Santesteban, 2004; Gollan & Ferreira, 2009; Verhoef, Roelofs, & Chwilla, 2009). Full reversal of language dominance effects suggests the operation of an inhibitory control process applied to the dominant language (Gollan & Ferreira, 2009; Kroll, Bobb, Misra, & Guo, 2008), and could also imply activation of the nondominant language (to the point that its accessibility exceeds that of the typically dominant