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Event-related potential measures of lexical activation in Alzheimer's disease ☆

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Introduction

Although the hallmark deficit in Alzheimer's disease (AD) is an impairment in episodic memory, language abilities are also impaired very early in the disease course (for a review, see Caramelli, Mansur, & Nitrini, 1998). Declines in semantic processing are well-documented, but less explored are the lexical abilities of AD individuals. However, there exists one study suggesting, on the basis of error patterns, that these patients exhibit a deficit in lexical activation (Paganelli, Vigliocco, Vinson, Siri, & Cappa, 2003). The present study aims to explore this possibility further, using an event-related brain potential (ERP) methodology to examine response to items that vary in terms of neighborhood density (ND).

ND refers to the number of words existing in the lexicon that differ from the target word by only one letter (e.g., carol has one neighbor, carob, while take has many neighbors, e.g., tale, make, toke, etc.). On the basis of behavioral studies, it has been claimed that high ND lexical items elicit higher levels of global lexical activity than low ND items due to partial activation of neighbors (Grainger & Jacobs, 1996). In a study examining ND effects on ERP response, Holcomb, Grainger, and O'Rourke (2002) found a larger N400 response to high ND than to low ND items in healthy young adults. The authors argue that this reflects higher global levels of lexical activation when a high ND item is seen, as postulated by Grainger and Jacobs (1996). We tested the hypothesis that deficits in lexical activation in AD will result in a diminished N400 effect to high ND items relative to healthy older adults.

Methods

Participants

Eleven AD patients (average age = 82.4, $SD = 5.4$) and 19 healthy older adults (average age = 74.2, $SD = 7.5$), all English-speaking, took part in the study. Control participants had no history of neurological or psychiatric disease. All participants gave informed consent to participate in the study.

Procedure

Participants read sentences terminating in 5- and 6-letter high and low ND lexical items ($n = 60$ in each condition). Sentences were presented one word at a time in the centre of the computer screen. Critical stimuli were balanced for frequency, bigram frequency, concreteness and imageability. Additional sentences with incongruent final stimuli ($n = 120$) are not included in the current analysis. Participants were asked periodic comprehension questions to ensure attentiveness.

EEG was recorded continuously from 32 electrodes, placed according to the 10–20 electrode system and referenced to linked ears. Epochs were time-locked to the critical stimulus (sentence-final word). Data were amplified in a DC-30 Hz bandwidth and sampled at 100 Hz for 1100 ms (100 ms prestimulus).

Results

After correction for eye movements and artefact rejection, average waveforms by individual and condition were calculated. Fig. 1 presents grand average waveforms at the FPz electrode for each participant group and condition.

Repeated-measures ANOVAs were used to examine ERP amplitude in three time windows for each participant group: 150–300 ms, 300–600 ms and 600–1000 ms post-stimulus onset. Older adults exhibited a significantly more negative response to high ND items than to low ND items throughout the epoch, significant in all sites in the 150–300 ms window ($p < .001$) and 300–600 ms window ($p < .005$) and in midline sites in the 600–1000 ms window ($p < .001$). AD patients exhibited precisely the reverse pattern: a significantly more negative response to low ND items throughout the epoch. This effect was significant in all sites in the early epoch ($p < .04$) and in left hemisphere sites in the 300–600 ms ($p < .04$) and 600–1000 ms ($p < .01$) windows.

Discussion

Consistent with previous literature (Holcomb et al., 2002), older adults manifested a significantly more negative-going waveform to high ND lexical items, beginning very early in the epoch and continuing throughout. In concordance with Holcomb et al. (2002), we suggest that this negativity indexes greater lexical activation when a high ND word is recognized.

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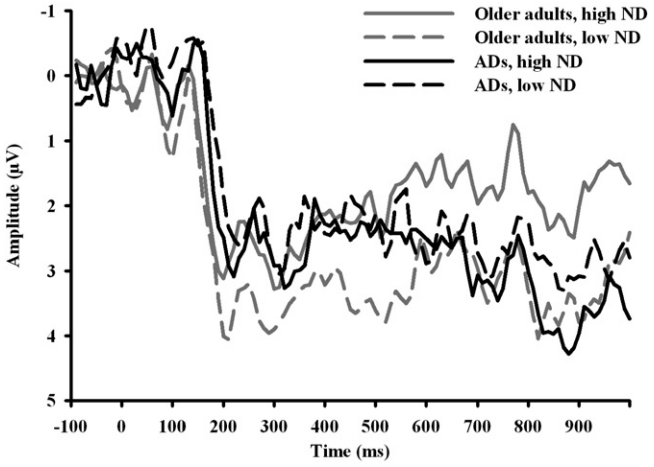

Fig. 1. Grand average waveforms at FCz electrode for high and low ND lexical items, AD participants and healthy older adults.

AD patients, in contrast, manifested a negative peak very early in the waveform to low ND items, which is maintained throughout the epoch and becomes left-lateralized in later time windows. A deficit in lexical activation in this population would predict a reduction in the distinction between high and low ND items, rather than a reversal in the effect. Thus, we suggest that a qualitatively different effect is indexed by this early negativity to low ND items. One possibility is that AD patients experience more difficulty in recognizing low ND items (for a discussion of early brain potentials reflecting increased difficulty in word recognition see, e.g., Martin-Loeches, 2007). In combination with the hypothesized reduction in lexical activation, resulting in diminished response to high ND items, such a reversal in response would obtain.

In conclusion, we found the predicted increased negativity to high ND items from very early in the epoch in healthy older adults, consistent with early activation of multiple lexical candidates. In AD patients, we found the reversed response pattern, and argue that this reflects a deficit in lexical activation, in combination with increased difficulty in recognizing low ND words.

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