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Speech Perception and Word Retrieval in Alzheimer's Disease (AD): A Pilot Study

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ABSTRACT: This research pilot project investigated speech and language related deficiencies in participants with and without Alzheimer's disease (AD). Information obtained from this study may lead to identification of early indicators of the disease that are not obtrusive. It was hypothesized that an individual with AD would still have storage of phonetic and lexical items, yet be unable to access them due to increased memory and processing demands (Bayles, Tomeoeda, & Trosset, 1992; Grossman & White, 1998). Participants consisted of one individual with Alzheimer's disease and a matched control without the disease. Neither participant had a prior history of speech or language problems and both were within age-appropriate limits for vision and hearing. The Alzheimer's disease was verified through use of the Mini-Mental State Examination (*MMSE*) and the *Arizona Battery of Communication Disorders in Dementia* (*ABCD*) criteria. In addition, the participant with AD showed early stages of the disease according to her medical records. The control participant was matched for age, socio-economic status (SES), education, monolingual English speaking abilities, and cultural background. The study used the following tests and procedures: the *Mini Mental State Examination* (*MMSE*), *the Boston Naming Test* (*BNT*), portions of the *Arizona Battery of Communication Disorders in Dementia* (*ABCD*), and a speech-perception gating task (Grossjean, 1996). The data were analyzed and reported using two-tailed t-tests and descriptively by comparing means. Significant differences were found between the participants on the gating measures of speech perception. Qualitative differences were found for the language tests. The hypothesis of impaired retrieval difficulties was supported. Further investigations with a larger sample are recommended.

WHAT IS ALZHEIMER'S DISEASE?

Alzheimer's disease (AD) is an irreversible, progressively degenerative disease that destroys a person's ability to think, remember, or use language (National Institute on Aging, 2002). Alzheimer's Disease is the most common form of dementia (Molloy & Lubinski, 1991; National Institute on Aging, 2002). Molloy and Lubinski (1991) define dementia accordingly:

> "Dementia is a common clinical syndrome characterized by a decline in cognitive function and memory from previously attained intellectual levels, which is sustained over a period of months or years. The deterioration is of such severity that it impairs the affected individual's ability to work and to perform activities of daily living, including communication." (p. 3)

It is helpful to review some aspects of the brain related to AD in order to gain a better understanding of the disease. Physiologically and neurologically, Alzheimer's disease (AD) has been identified as the increase and formation of beta-amyloid plaques (caused by an increase of A-beta proteins) and the creation of neurofibrillary tangles. The National Institute on Aging (2002) stated that "Plaques are dense, mostly insoluble deposits of protein and cellular material outside and around neurons. Tangles are insoluble and twisted fibers that build up inside the nerve cell" (pp. 14-15). Plaques form when a protein, i.e., amyloid precursor protein (APP), is inadvertently snipped. It is not known why these proteins are cut. One of the resulting fragments is beta-amyloid. Beta-amyloid fragments clump together to form the damaging plaques.

Neurofibrillary tangles arise when neuronal structures, i.e., microtubules, disintegrate and collapse a neuron's ability to send and receive signals (National Institute of Aging, 2002). This occurs because healthy neurons require a tau protein in order for the microtubules to remain stable. In some way, Alzheimer's disease chemically changes the tau protein and consequently the neuron disintegrates, leading to the loss of communication abilities.

Other factors affect the inability of a brain with Alzheimer's disease to think, remember, and communicate. Glutamate is a neurotransmitter inhibitor, i.e., it reduces neural transmissions. For unknown reasons, Alzheimer's patients have abnormally high levels of glutamate, so that their brain cells become insensitive to normal glutamate bursts that aid in new memory formation (National Institute on Aging, 2002). Glutamate helps sustain memories when it is released in short bursts; however, it kills neurons when it is abnormally high or elevated. Unfortunately, patients with AD have higher than normal levels of glutamate, thus increasing brain neuron-cell loss. Loss of acetylcholine (a neurotransmitter critical to memory and cognition) in AD has also been noted (Cowley, 1999).

What Communication Difficulties Arise From Alzheimer's Disease (Ad)?

The clinical diagnosis of AD is usually made during the first stage of disease development. Most clinicians and researchers agree to a three-stage progression of AD, i.e., mild, moderate, or severe AD. Signs of early Alzheimer's disease include (but are not limited to) the following: (a) memory loss, (b) confusion, (c) poor judgment, (d) increased time to process information, and (e) possible mood and personality changes (National Institute of Aging, 2002). With regards to communication, individuals with AD may have difficulties perceiving speech, retrieving words, and comprehending sentences. Impaired memory and cognitive abilities may affect the individual's language in selecting vocabulary and creating sentences in order to speak and communicate.

Certain research in communication disorders regarding AD has been conducted in the following areas: (a) speech perception (Carlesimo, Mauri, Marfia, Fadda, & Turriziani, 1999), (b) auditory priming/cuing (Verfaellie, Keanne, & Johnson, 2000), and (c) language in AD (Balota & Duchek, 1991; Hamberger, Friedman, Ritter, & Rosen, 1995). However, further information regarding how individuals with AD process both speech and language and how individuals with AD retrieve words to communicate is still needed. Impairment in communication appears to be a major feature of AD and also a much needed area of research (Malloy & Lubinski, 1991).

It has been suggested that individuals with AD display intact implicit memory, yet display explicit memory deficits (Carelesimo, Mauri, Marfia, Fadda, & Turriziani, 1998). Implicit memory, sometimes referred to as procedural memory, is defined as memory without awareness (Malloy & Lubinski, 1991). Explicit memory is defined here as the conscious recall of previously learned information. Carelesimo et al. (1998) reported that individuals with AD also show less than normal repetition priming, i.e., auditory or visual cuing of information. That is, AD patients seem to show dissociation between perceiving information and cognitive abilities conceptualizing the information.

It seems well established that semantic knowledge is affected early in the Alzheimer's disease process (Nebes, 1989) while conceptual knowledge seems to be less affected (Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991). Therefore, Carelesimo et al. (1998) decided to investigate the relationships among phonotactic, lexical (i.e., at the sound and word level), and conceptual factors in a repetition priming paradigm. They decided to use a stem completion task (i.e., the study participant was given an incomplete word, the first three letters of the word, and he/she had to complete the word given the initial portion of the word or stem). Carelesimo et al. (1998) incorporated two conditions of priming, a graphemic condition and a semantic condition. Under the graphemic cuing or priming, the participant had to count the number of syllables in the presented words, while under the semantic priming condition the participant had to generate word meanings from the presented words. Then, the participants were presented with only parts of the word (i.e., the stem) in a later task. Therefore, the dependent variable was the latency in the pronunciation of the stem completion task. Implicit and explicit memory cues were also tested. Under the implicit task, no cuing was given, while under the explicit task the participants were foretold that a memory task was to be completed. The results indicated that a dissociation between normal lexical but deficient conceptual priming was evident with the AD participants in experiment one; however, no dissociation was found in experiment two with intramodal (auditory stimuli) and crossmodal (auditory and visual stimuli) presentation of the stimuli. Carelesimo et al. (1998) stated that, "in conclusion, the priming effect elicited by Stem Completion in various groups of patients with AD is not consistent" (p. 1058).

Verfaellie, Keane, and Johnson (2000) investigated the status of auditory perceptual priming in individuals with and without Alzheimer's disease (AD). It has been postulated that normal perceptual priming (i.e., tasks where priming reflects activation of perception, such as visual word identification) is seen in individuals with AD; however, priming on conceptual tasks (e.g., identifying the grammaticality of an utterance) may be impaired. The participants in this study were required to identify words presented in noise (i.e., the stimulus was presented auditorally with noise embedded in the background). The participants then had to respond to which words they thought they had heard and to remember if the word had been previously presented. In these experiments, Verfaellie et al. (2000) found that individuals with Alzheimer's disease showed intact priming in an auditory perceptual identification task. The individuals with AD were capable of identifying and discriminating at the phoneme and sound level. Hence, the findings seemed to suggest that auditory perceptual memory is intact in individuals with AD. These findings also suggested that word-retrieval difficulties seemed to occur in lexical access rather than implicit phonological identification and discrimination of phonemes.

Balota and Duchek (1991) studied semantic priming effects, lexical representation, and the influence of context on meaning in individuals with and without Alzheimer's disease. The participants pronounced the prime words under four conditions of word relatedness. These consisted of concordant (music-organ-piano), discordant (kidney-organ-piano), neutral (ceiling-organ-piano), and unrelated (kidney-ceiling-piano) conditions. The participants were visually shown the stimuli words (i.e., one at a time) and then were to pronounce each word as it was visually presented on a computer screen. Their responses were timed in terms of response latency. The results (i.e., with regards to lexical repetition) indicated that individuals with AD showed relatively little deficit in lexical repetition as measured by pronunciation latencies. That is, the AD participants demonstrated only minor deficits in implicit memory or procedural memory tasks. Balota and Duchek (1991) also found that "semantic context does not influence the selection of meaning in SDAT [senile dementia of the Alzheimer type], as it does in healthy older adults" (p. 196). They concluded that individuals with AD demonstrated a failure of the inhibitory system to negate inappropriate word selections.

Hamberger, Friedman, Ritter, and Rosen (1995) investigated understanding of semantic relationships in individuals with and without Alzheimer's disease. Specifically, the participants were asked to indicate if the final word in a sentence made sense or was nonsense. Sentences were constructed under four conditions of relatedness: (a) best completion/sense (e.g., "The guard sounded the alarm"), (b) related sense (e.g., "The guard sounded the bell"), (c) related /nonsense (e.g., "The guard sounded the lock"), and (d) unrelated/nonsense (e.g., "The guard sounded the molars"). Electroencephalograph (EEG) results were obtained. The dependent variables consisted of reaction times in judging the sentences. Event related potential waveforms from the EEGs were also analyzed. Their results indicated that the individuals with AD experienced "systematic decomposition of the semantic gradient" (p. 54). However, for the individuals with AD the semantic information required to distinguish semantically related items is retained at some fundamental level (p. 54). Hamberger et al. (1995) concluded that the AD participants had difficulty in accessing and using semantic information, rather than showing a loss or disorganization of the information. They stated that, "Thus, although PAD patients were unable to produce semantic information about a particular word, they appeared to have access to semantic information about the same item when the task was modified" (p. 55). In summary, these studies have demonstrated inconsistent results with regards to perceptual identification of phonemes, graphemes, and conceptual identification of words. The question of whether retrieval difficulties lie in lexical access (involving explicit memory) rather than phonological identification and discrimination of phonemes (involving implicit memory) still needs to be further investigated.

Statement Of The Problem

It is important to know how speech input and lexical processing affect language abilities in individuals with Alzheimer's disease (AD) when compared to matched normal adults. This contrastive information is essential when applied to clinical situations (e.g., conducting therapy with patients with AD) in order to clarify effective language and memory strategies and what type of input will best facilitate language abilities. It is believed that an AD participant will show difficulties when memory tasks are increased in comparison to a normal matched-control participant. It is also anticipated that lexical retrieval for the AD participant will be difficult.

Hypothesis

It was hypothesized that an AD participant may still have storage of phonetic and lexical items, yet may be unable to effectively retrieve words due to increased processing and memory demands. Hence, through a series of tasks and tests, it may be possible to contrast various retrieval mechanisms, i.e., administration of the *Mini Mental State Examination* (*MMSE*) (Folstein, Folstein, & McHugh, 1975), administration of the *Boston Naming Test* (*BNT*) (Kaplan, Goodglass, & Weintraub, 1976), administration of portions of the *Arizona Battery of Communication Disorders in Dementia* (*ABCD*), and through administration of a speech perception forward gating procedure (Grosjean, 1996; 1988; 1982).

METHODOLOGY

Participants

Two participants, one with AD and a matched normal without AD, were utilized for this pilot study. The participants were matched for approximate age, SES, education, monolingual English speaking abilities, and cultural background. Alzheimer's disease was verified through the following means: (a) use of the Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), (b) administration of the Listening Comprehension subtests of the Arizona Battery of Communication Disorders in Dementia (ABCD) (Bayles & Tomoeda, 1993), and (c) examination of the patient's medical records. The participant with Alzheimer's disease demonstrated a MMSE score of 15 (a score of 19 or less indicates presence of dementia). The participant with AD scored 50% on the three listening comprehension ABCD subtests. Her medical records indicated a probable diagnosis of early Alzheimer's disease.

The participant with AD showed no other concomitant speech, language, or hearing difficulties (e.g., such as a stroke). The matched control participant showed no previous history of speech, language, hearing, or other communication difficulties. Both participants were monolingual English speakers 60-70 years of age. Both participants were within normal limits for age for vision and hearing as determined through participant self-report.

Materials

The following materials were used for this study:

1. Tests administered to examine cognition and memory.
   These consisted of:
   a. the *Mini Mental State Examination* (*MMSE*) (Folstein, Folstein, & McHugh, 1975), and
   b. the *Arizona Battery for Communication Disorders in Dementia* (*ABCD*) (Bayles & Tomoeda, 1993);
2. A test was administered to elicit lexical recall consisted of the *Boston Naming Test* (*BNT*)(Kaplan, Goodlglass, & Weintraub, 1976); and
3. A forward gating procedure was administered (i.e., where words are presented in increments of 60-70 ms for each gate with words increasing in length by gates) to test speech perception. The researcher developed a set of stimuli (20 words) consisting of

high frequency words containing initial consonant-consonant-vowel or initial consonant-vowel combinations. Words differed according to voiced (e.g., ball) versus voiceless (e.g., pall) contrasts.

Randomization of Words for the Gating Task

A random selection of gated words was completed in order to produce a master list. One fluent, English-speaking (female) read the test words at a normal rate into a computer that digitally recorded the stimulus test words at 44.1 kHz. A range of values for the gates (i.e., from 60-70 ms) was used so that the segments were cut at zero crossings to avoid artifact sounds (i.e., adding to distortion). The first gate consisted of the first 50-70 ms of the target word. The second gate consisted of the first gate and the next 50-70 ms of the word and so on until the end of the word was given.

Instructions for the Gating Task

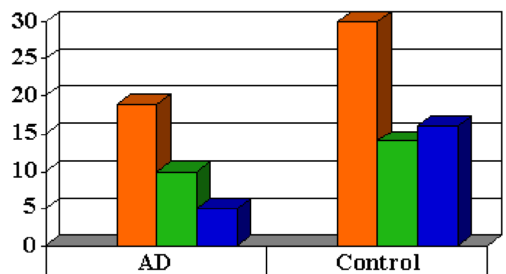
The experimenter explained the task to the participants verbally. The participants were told that they would hear the words broken into small pieces that would increase in length. They were instructed that their task was to identify the gated word by saying it out loud. This identification occurred at the end of each pause between gates. They were also instructed to rate by percentage their confidence in their word choice (i.e., either 100% confident or not).

Equipment

An Apple Omnidirectional microphone was positioned close to the speaker's mouth, per the manufacturer's instructions, to record the test words. Test words were recorded to an Apple G4 computer. The Apple computer soundcard is built into the motherboard sampling sound at 44.1 kHz and 16-bit quantization. An Apple G4 Macintosh, 733 MHz, computer running Soundstudio 2.1 software and Praat 4.02 software were used for acoustic analysis. The Soundstudio 2.1 software was used to record the test words, while the Praat 4.02 software was used to segment and gate the target words. Test words were played back by means of an iMac G3 computer sampling sound at 44.1kHz and 16-bit quantization. The participants heard the test words through Altec Lansing Stereo computer speakers with sound at a comfortable level of 60-70 dB. This was verified by asking the participants if the sound was an appropriate level. Response forms were used to collect the participant's responses on successive gates as to what word they believed they heard, until they were 100% confident of their response. Words were randomized to control for presence for initial 10 English words containing initial voiced CC clusters, and 10 English words containing initial voiceless CC clusters.

RESULTS

Significant differences were found on voiced words (e.g., ball) in the speech perception tasks between the AD and matched control participants using a two-tailed t-test (t=22.898, df=1, p= .028) and on voiceless words (e.g., pall) (t=29.000, df=1, p=. 022). Participant scores were also examined according to diagnostic test scores obtained from the *Mini-Mental State Examination* (*MMSE*), the *Boston Naming Test* (*BNT*), and the *Arizona Battery of Communication Disorders in Dementia* (*ABCD*). Results revealed non-significant differences. However, a profile of these scores indicated noted differences. Refer to Figure One.



Test Scores	AD	Control
MMSE	19	30
BNT	10	14
ABCD	5	16

Dennis Figure 1

Figure 1. Performance on the *Mini Mental State Examination, the Boston Naming Test,* and the *Arizona Battery of Communication Disorders in Dementia.*

CONCLUSIONS AND DISCUSSION

The results from this pilot study, albeit limited, indicated significant differences on the gating task between the participant with AD and the normal-matched control participant. Speech perception (using the gating methodology) appeared to be a more sensitive measure of on-line and off-line mental processing in Alzheimer's disease than measures of language and memory. The potential for diagnostic tools using speech perception seem warranted.

Results from the use of the *MMSE*, *BNT*, and *ABCD* are tentative due to the small sample (n=2) of this preliminary pilot study. However, naming, memory, and listening comprehension appeared to be partially compromised with the participant with AD.

It was hypothesized that an AD participant would retain storage of phonetic and lexical items, yet be unable to effectively retrieve words because of increased processing and memory demands. In sum, it appeared that the participant with AD was still able to retrieve and recall words (note the results from the MMSE, BNT and ABCD), however, with much reduced capabilities. The participant with AD recalled fewer words and at a slower rate when compared to the control participant. Hence, storage appeared to be intact; however, retrieval abilities appeared to be compromised.

These findings support the earlier work of Verfaellie, Keane, and Johnson (2000), Balota and Duchek (1991), and Hamberger, Friedman, Ritter, and Rosen (1995). These results are in partial conflict with those obtained by Carelesimo et al. (1998). It should be noted that different methodologies and stimuli were employed to contrast perceptual versus conceptual identification in all of the above-mentioned studies. Three of the four reviewed studies (Balota & Duchek, 1991; Hamberger, Friedman, Ritter, & Rosen 1995; Verfaellie, Keane, & Johnson, 2000) are consistent with the findings from this study. However, the findings from this study are partially inconsistent with experiment two of the Carelesimo et al. (1998) study. Therefore, the inconsistent results may lie with the nature of the task in the Carelesimo et al (1998) study, i.e., either the stem completion task or the presentation of cross-modality stimuli confounded the results. It appeared that the natures of the stimuli in this pilot study were robust by the significant or notable differences between the normal participant and the participant with AD. In conclusion, future studies (with a more robust sample) investigating speech perception, memory, and naming abilities in participants with and without AD appear justified and are recommended.

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