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Research report

A longitudinal study of semantic memory impairment in patients with Alzheimer's disease

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ABSTRACT

Introduction: The present study explored the nature of the semantic deterioration normally displayed in the course of Alzheimer's disease (AD). The aim was to disentangle the extent to which semantic memory problems in patients with AD are best characterized as loss of semantic knowledge rather than difficulties in accessing semantic knowledge.
Method: A longitudinal approach was applied. The same semantic tests as well as same items were used across three test occasions a year apart. Twelve Alzheimer patients and 20 matched control subjects, out of a total of 25 cases in each group, remained at the final test occasion.
Results and Conclusions: Alzheimer patients were impaired in all the semantic tasks as compared to the matched comparison group. A progressing deterioration was evident during the study period. Our findings suggest that semantic impairment is mainly due to loss of information rather than problems in accessing semantic information.

1. Introduction

Semantic memory impairment is common in Alzheimer's disease (AD) (Adlam et al., 2006; Binetti et al., 1995; Bäckman and Lipinska, 1993; Daum et al., 1996; Hodges et al., 1992; Spaan et al., 2005). Although semantic impairment might not be the first or most sensitive early indicator of AD, all AD patients show semantic memory deficits at later stages of the disease (Hodges and Patterson, 1995).

Semantic memory is culturally shared and can be described as context-free knowledge about the world, objects and facts (Tulving, 1972). Impairment is indicated by problems in naming objects and pictures, in defining objects, and by poor comprehension of oral and written language. Deficiencies in semantic memory are often assessed by tests measuring confrontation naming, categorical verbal fluency or word to picture matching (Bayles and Tomoeda, 1983; Henry et al., 2004; Lonie et al., 2009). Following a series of important papers by Shallice and Warrington (e.g., Shallice, 1988; Warrington and Shallice, 1984), two main hypotheses have been suggested to account for semantic memory impairments, including those observed in patients with AD (see also Hodges et al., 1992). One explanation highlights loss of semantic information and it is assumed that semantic representations in memory decline gradually across time (i.e., the degraded store view). A second hypothesis claims that semantic deficits are due to difficulties

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in accessing or retrieving information stored in semantic long-term memory (i.e., the degraded access view).

In a seminal study, Chertkow and Bub (1990) used an item-to-item specific test and observed error consistency across test trials, providing support for the degraded store view. In this study, the patients were first asked to name pictures and subsequently to perform a "same category word to picture matching" task. There was a reliable overlap between loss of name production and name comprehension such that pictures named correctly were more likely to be chosen in a word-to-picture matching task than pictures not named correctly (see also Alathari et al., 2004; Bayles et al., 1999; Binetti et al., 1995; Garrard et al., 2005; Hodges and Patterson, 1995; Hornberger et al., 2009; Martin and Fedio, 1983; Salmon et al., 1999a for similar procedures). Several other researchers have described a breakdown in the structure and organization of semantic memory in patients with AD (for review see Salmon et al., 1999b).

In contrast to the study of Chertkow and Bub (1990), Nebes et al. (1984) argued that there might exist important differences in task demands; for example, conscious and effortful recall of semantic knowledge (such as verbal fluency or picture naming tasks) versus automatic and non-effortful activation of semantic knowledge (such as various priming tasks). In their study, AD patients performed equally as well as controls on automatic priming tasks, despite a substantial impairment when the task required conscious recall of semantic knowledge (for similar views on other forms of memory impairment, see Nilsson et al., 1989; Titov and Knight, 1997.) Based on these findings, Nebes et al. (1984) argued that representations of semantic knowledge are mainly intact in AD and that a semantic deficiency is better accounted for by an impairment in accessing or retrieving semantic information. To date, there have been several studies suggesting that AD patients suffer from retrieval problems rather than loss of knowledge (Bäckman and Lipinska, 1993; Daum et al., 1996; Duong et al., 2006; Laatu et al., 1997; Lipinska and Bäckman, 1996; Nebes et al., 1989).

Evidence to support either the loss or the access theory is often provided by performing cross-sectional studies, error consistencies across tests or item-to-item specific loss. In addition, most research focusing on a decline in semantic memory has involved short time intervals between test occasions. Thus, the possibility of distinguishing between the degraded store and the degraded access view of semantic memory problems in AD patients has been limited. In the present study we addressed these methodological problems by performing a longitudinal study of AD patients repeating the same tasks three times at a yearly rate. Identical tests of semantic memory and identical test items were used on all three test occasions, and thus both task demands and semantic representations tested were the same over time. More recently, longitudinal studies assessing semantic memory have demonstrated a loss of semantic attributes over time (Giffard et al., 2002; Moore et al., 2004). However, the question about access or loss has not been explicitly addressed in these studies.

More specifically, our test battery comprised three tasks. The first involved word reading. Based on previous studies, it was expected that word reading ability should be more or less intact in AD and represents a highly automatized ability (Cummings et al., 1986; Diesfeldt, 1992; Nebes et al., 1984; Nelson and O'Connell, 1978; O'Carroll and Gilleard, 1986; Schwartz et al., 1980; Sharpe and O'Carroll, 1991). The second task was word comprehension. This task was assumed to involve conscious processing of semantic knowledge. A third task, also highlighting conscious and presumably effortful retrieval of semantic knowledge, was a semantic attribute judgment task. The loss hypothesis predicts that the same semantic information would fail to be comprehended across different tasks within one test occasion and across test occasions. The access hypothesis predicts random absence of specific semantic information across tasks within one test occasion as well as across test occasions. The approach to test these hypotheses by examining item-by-item consistency across tests has been used in previous studies (e.g., Garrard et al., 2005; Hodges et al., 1996). Our longitudinal design extends this approach by examining item-by-item consistency within the same AD patients across time.

To summarize, the purpose of the present study was twofold: to examine how AD patients differ from matched controls in semantic memory performance over time, and to study if the pattern of semantic memory impairment in patients with AD is best characterized as loss of semantic knowledge or difficulty in accessing semantic knowledge.

2. Method

2.1. *The initial samples of participants*

Initially 25 patients were included in the study, all diagnosed with possible AD (duration of disease $m = 3.4$ years). The diagnoses were established according to the DSM-IV criteria (American Psychiatric Association, 1994) and based on neuroradiological (e.g., CT scan), neurological, neuropsychological and medical evaluations at the University Hospital in Linköping and at the Vrinnevi Hospital in Norrköping. A comparison group of 25 people matched by age, gender and education were also included in the study.

Drop-out. The participants were tested on three occasions, 1 year apart (±1 month). During the course of the study, three of the AD patients died and 10 showed severe cognitive declines, thus being untestable in some or all tests administered during the test occasions. At the third and final test occasion, 12 out of 25 AD patients completed the full test battery. The matched comparison group consisted of 20 participants at the third and final test occasion. Drop-out was due to reasons unrelated to the purpose of the study.

2.2. *The final sample of participants*

The mean age in the AD group ($n = 12$) at the first test occasion was 77 years (SD = 5.5) and their mean level of education was 8.2 years (SD = 2.1). The mean age in the comparison group ($n = 20$) was 73 years (SD = 4.7) and their average level of education was 9.7 years (SD = 3.5) (Table 1).

Analysis of variance (ANOVA) revealed that neither age, $F(1, 28) = 3.74$, $p > .05$, nor level of education, $F(1, 27) = .40$, $p > .05$, differed significantly between the two groups.