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Research paper

Knowledge of semantic features in mild cognitive impairment

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ABSTRACT

Mild cognitive impairment (MCI) is defined as impairment in cognitive function in the absence of dementia, and in many cases it represents a prodromal state of dementia. Semantic function is impaired in MCI, but the exact nature of the impairment remains to be understood. The present study aimed to investigate the nature of this impairment using two semantic feature tasks. In the first, participants generated the most specific shared semantic feature for word pairs (e.g., how is a tiger like a zebra?) and in the second they selected the shared feature in a multiple choice format. Half of the stimuli were biological kinds, and half were artifacts. Participants were cognitively healthy older adults (n = 39) and people with MCI (n = 21). Overall, MCI participants committed more errors than control participants, with lower performance in biological items relative to artifacts. MCI participants also committed proportionally more superordinate errors than control participants, suggesting greater impairment in lower-level semantic features. MCI participants did not benefit from the multiple choice format, suggesting degradation of core semantic representations. In contrast, correlations were observed between performance on the experimental task and verbal fluency measures, but not semantic function, indicating selection and retrieval deficits in MCI. Thus, we hypothesize that both process and content impairments play a role in declines in semantic function in MCI.

1. Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that affects multiple cognitive domains, including memory, executive function, and language. It is now well-established that cognitive deficits are observed prior to the onset of frank dementia, and research in recent years has focused on the construct of mild cognitive impairment (MCI). Mild cognitive impairment was first defined by Petersen et al. (1999) as an impairment in objective and subjective memory in the context of intact cognition in other domains, and an absence of dementia. MCI is a major risk factor for dementia, with around 6–15% of people with MCI developing dementia per annum, versus 1–2% in the general elderly population (Petersen et al., 2009).

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Although the original criteria indicated that people with MCI do not have impairments in cognitive domains other than memory, subsequent research has indicated that a subset of these patients show deficits in domains beyond memory function (e.g., Adlam, Bozeat, Arnold, Watson, & Hodges, 2006; Belleville, Chertkow, & Gauthier, 2007). More recent criteria (Petersen et al., 2001) have emphasized that MCI may take different forms: specifically, there exist amnestic and non-amnestic variants (depending on whether memory function is compromised or not), and deficits may be observed in just one cognitive domain (single-domain MCI) or across two or more domains (multiple-domain MCI).

1.1. Semantic function in MCI

While memory function in MCI and AD is typically assessed using tasks of episodic memory, it is also well-established that semantic memory is affected in MCI and AD (for a review, see Taler & Phillips, 2008). Semantic memory encompasses a general knowledge about the world acquired over a lifetime. It refers to the memory of objects, facts and concepts, as well as words and their meanings, and gives meaning to our sensory experiences (Hodges, Salmon, & Butters, 1992). Several decades of research have led to the conclusion that semantic memory is affected in AD, as reflected by impaired performance in tasks such as verbal fluency and confrontation naming (Weintraub, Wicklund, & Salmon, 2012). Previous research has revealed declines in semantic processing in MCI (see Taler & Phillips, 2008). However, the exact nature of the impairment is not entirely clear (e.g., Adlam et al., 2006; Brandt & Manning, 2009), and performance is strongly influenced by the tests used (e.g., the categories selected in a verbal fluency task, Brandt & Manning, 2009).

Semantic knowledge—that is, our knowledge about objects and concepts—can be characterized in terms of semantic features (see, e.g., Cree & McRae, 2003). Within this framework, a given object or concept may be defined in terms of a set of features; for example, a zebra is characterized by features such as <has four legs> and <has stripes>. These semantic features can be classified as distinctive or non-distinctive, depending on how many concepts share the feature. For example, <has four legs> may be classified as a non-distinctive feature because it is shared across many concepts, while a feature such as <has stripes> may be classified as distinctive.

This framework can be useful for understanding the nature of the semantic deficit in AD. Impairments in semantic knowledge may take the form of loss or deterioration of features within a semantic representation. In AD, distinctive features are more vulnerable than shared features (Flanagan, Copland, Chenery, Byrne, & Angwin, 2013; Garrard, LambonRalph, Patterson, Pratt, & Hodges, 2005; Laisney et al., 2011). Loss of distinctive features makes it more difficult to distinguish between concepts that belong to the same category, while category knowledge remains intact (Flanagan et al., 2013). Thus, people with AD would be expected to produce more superordinate errors in semantic tasks than cognitively healthy older adults, a finding that has indeed been reported in the literature (e.g., Lukatela, Malloy, Jenkins, & Cohen, 1998).

Little is known with respect to alterations in representation and/or processing of semantic features in MCI. Joubert et al. (2008) assessed knowledge about common objects, famous people and famous public events, and found that all domains were impaired, with a greater degree of impairment observed in knowledge about famous people and events relative to knowledge about objects. The authors suggest that conceptual entities with "distinctive and unique properties" are more affected in MCI than those that do not possess such properties. However, much remains to be understood about the effect of MCI on processing of semantic features.

1.2. Category-specific deficits

Loss of semantic knowledge can take the form of a category-specific deficit, whereby items belonging to specific categories are more impaired than items belonging to other categories (Cree & McRae, 2003). The majority of category-specific deficits manifest in either biological (e.g., animal, vegetable) or artifact categories (e.g., clothing, household goods) (e.g., Cree & McRae, 2003; Whatmough et al., 2003). In AD, specific deficits in both biological and artifact categories have been reported, although the majority of studies have found a greater deficit in biological categories (for a review, see Capitani, Laiacona, Mahon, & Caramazza, 2003). These discrepancies may be attributable to differences in methodological approaches, such as failure to control for item frequency (Hernández, Costa, Juncadella, Sebastian-Galles, & Rene, 2008). Whatmough et al. (2003) studied a large group of people with MCI and different degrees of severity of AD, and found that the category effect increased as anomia worsened, and that only participants with naming scores that fell into the range of cognitively healthy older adults showed no category effect.

Category-specific deficits are typically observed in tasks that require naming, recognizing or defining the item (Tippett, Grossman, & Farah, 1996). Whatmough et al. (2003) suggest that the greater impairment often observed for biological kinds may occur because biological items possess more intercorrelated features than artifacts. For example, "lion" may be more difficult to recognize than "hammer" because a lion closely resembles other animals physically as well as semantically, while a hammer is more distinct in its structure and use. Thus, the greater distinctiveness of artifacts relative to biological items results in greater resistance to the erosion of semantic knowledge.

1.3. Access versus representation

Another longstanding debate with respect to the impact of AD on semantic knowledge is whether semantic knowledge is truly lost, or whether the knowledge simply cannot be accessed (see Hodges et al., 1992; Nebes, 1989). While there exists