I don't know what I know: Evidence of preserved semantic knowledge but impaired metalinguistic knowledge in adults with probable Alzheimer's disease*

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Running header: Impaired metalinguistic knowledge in dementia

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Abstract

Background. At what point does “not telling” become “not knowing”? Previous research shows that Alzheimer’s disease (AD) affects people’s ability to define words, primarily, it has been thought, because AD destroys the semantic representations of words that the patients can no longer define. We investigate an alternative hypothesis, which is the idea that AD affects metalinguistic ability, which in turn affects people’s ability to produce good definitions.

Aims. Does AD affect metalinguistic abilities? Are definitions poor because people lose semantic information, or because they lose the knowledge of what constitutes a good definition?

Methods & Procedures. We first established what constitutes good definitions of a set of words denoting animate and inanimate concepts. We then asked elderly people with AD to define these words. As expected, their definitions were very poor. However, we then asked them forced and open-choice questions about the information that they omitted from their definitions.

Outcomes & Results. We show that people with AD can access semantic information that they appear to have lost. The AD group performed significantly worse than control participants on a word definition task, but importantly, some of the information they did not provide spontaneously was offered after questioning

Conclusions. We conclude that although our participants with AD have lost some semantic knowledge, on at least some occasions they do not provide information that they do still know because of a metalinguistic impairment. In particular, the participants with AD no longer understand what constitutes a good definition. We argue this metalinguistic impairment results in part from frontal atrophy. Our results have the important consequence that just because a person with AD does not offer information, even when asked, does not mean that they do not know it.

I don't know what I know: Evidence of preserved semantic knowledge metalinguistic deficits in adults with probable Alzheimer's disease

Do people with probable Alzheimer's disease (AD) know more than they say? The apparent loss of knowledge is one of the most striking and distressing aspects of the cognitive changes brought about by progressive disorders such as AD. There has been much debate in the literature about whether knowledge is truly lost or whether it becomes inaccessible (Bayles, Tomoeda, Kaszniak & Trosset, 1991; Chertkow & Bub, 1990; Hodges, Salmon & Butters, 1991; Nebes, 1989, 1994; Nebes, Martin & Horn, 1984). In this paper we explore an alternative hypothesis: that at least some of the time, people with AD still possess and can access some of the information that they appear to have lost, but do not produce it spontaneously because they no longer fully understand the demands of the tasks in which they engage. That is, they possess a *metalinguistic deficit*.

The loss of linguistic abilities is a prominent feature of AD (for reviews see Harley, 1998; Nebes, 1989). People with AD show a wide range of language impairments from an early stage of the disease, including word-finding difficulties (Astell & Harley, 1996, 1998; Kempler, 1988), poor comprehension (Emery, 1985, 1996), and impoverished discourse (Hutchinson & Jensen, 1980), although syntactic comprehension and knowledge may remain relatively intact (Rochon, Kavé, Cupit, Jokel, & Winocur, 2004).

The wide range of difficulties is not surprising considering the nature of AD pathology: given this non-focal and non-uniform pathology, we expect variable and wide-ranging linguistic impairments. Until recently few people have identified frontal-lobe disturbance as a feature of early-stage AD, with the general belief being that frontal damage only manifests later in the progression of AD and only secondary to more posterior (Broks, Lines, Atchison, Challenor, Traub, Foster et al., 1994) and subcortical (hippocampal) damage (Ball, Fisman, Hachinski, Blume, Fox, Kral et al., 1985). However, recent studies of executive impairments in AD suggests that frontal-lobe damage does in fact occur much earlier than has previously been acknowledged (Baddeley, Baddeley, Bucks & Wilcock, 2001; Collette, Nan der Linden & Salmon, 1999; Lafleche & Albert, 1995; Perry & Hodges, 1999). Baudic, Dalla Barba, Thibaudet, Smagghe, Remy and Taykov (2006) not only found evidence of executive impairments in mild AD patients, but also found that executive impairments preceded the disturbance of language, attention and constructional praxis. Identifying the specific neural underpinnings of executive impairments and therefore also identifying which frontal regions are damaged in AD however remains problematic.

Based upon the evidence to date we believe that the frontal-lobe disturbances found in AD will ultimately affect metalinguistic processes. We do not however propose to identify the exact neural underpinnings of metalinguistic functions. Our proposal of frontal-lobe involvement is thus based upon two things. First, metalinguistic abilities clearly draw upon a number of high-level executive functions such as awareness, theory of mind, monitoring, planning, controlled processing and updating (Bialystok & Ryan, 1985; Doherty & Perner, 1998; Gombert, 1992; Karmiloff-Smith, 1986). These are all cognitive functions that we know to some degree, rely on the integrity of the frontal-lobes (Norman & Shallice, 1986; Rympa, Prabhakaran, Desmond, Glover & Gabrieli, 1999; Shallice, 2002; Torralva, Kipps, Hodges, Clark, Bekinschtein, et al., 2006). Second, because AD results in executive impairments it is reasonable to assume that metalinguistic functions will also be affected. However to attempt to localise metalinguistic processes to specific regions of the brain is by its very nature a fruitless exercise. We therefore propose that our examination of metalinguistic function will afford us a better understanding of how high-level language functions are affected in AD and that the evidence to date provides us with reason to believe that executive and frontal-lobe impairments will contribute in some way to the metalinguistic disturbance.

Differences among tasks will lead to differences in performance: those tasks that are more reliant on conscious access to information, essentially those tasks that place grater demands on executive function, will cause people with AD more problems than tasks that do not place demands on executive function.

Although most psycholinguistic research is on *automatic* language processing (such as much of word recognition and production and parsing), language tasks differ in the amount of *non-automatic* processing involved. Automatic language processing is mandatory, fast, and does not use general resources. Non-automatic language processing is reliant on conscious access and places demands on general resources. Non-automatic processes play a central role in controlling and manipulating automatic language processes. As they involve executive processing, they depend on the integrity of the frontal lobes. Hence any pathology that disrupts the frontal lobes (such as AD) will affect the efficacy of the non-automatic processes that control language. We know that people with AD are impaired on tasks such as word naming and memory retrieval that have a large automatic component, but much less is known about the effects of AD on non-automatic language processing. In particular, we do not know if some of the observed semantic deficits might result from impaired non-automatic language-control processes.

Recent evidence shows that AD affects general executive processing (Collette, Delrue, Van Der Linden, & Salmon, 2001; Lambon Ralph, Patterson, Graham, Dawson, & Hodges, 2003), and indeed may do so quite early in the disease (Baudic, Dalla Barba, Thibaudet, Smagghe, Remy, & Traykov, 2006). Although there are few overt examinations of non-automatic language-control processes within the AD literature, there is clear evidence that such processes are affected. For example, people with AD perform consistently poorly on tests of verbal fluency (Butters, Granholm, Salmon, Grant & Wolfe, 1987; Diesfeldt, 1985; Hodges, Salmon & Butters, 1992; Martin & Feido, 1983). A recent meta-analysis of verbal fluency performance in AD shows that the spontaneous generation of items from semantic categories is more difficult than the spontaneous productions of letters or phonemes (Henry & Crawford, 2004; Henry, Crawford, & Phillips, 2004). Emery (1996) argued that people with AD are more impaired on category-fluency tasks because these tasks are "meta-naming tasks". Meta-naming tasks require increased levels of awareness, attentional control and monitoring than automatic tasks like confrontation naming because they require as many names to be generated as possible from a specific category rather than generating a single name or term. This task requires people, among other things, to identify suitable items for output, to maintain the strategy of generating as many items as possible, to monitor the output to avoid repetition, and to change strategies if the output is exhausted. The individual is therefore also required to keep the demands of the task in mind for a longer period of time, which in turn places further demands on the executive system. Thus, category-fluency tasks reveal greater impairments because they have more processing demands and require more executive control than other naming tasks.

Other examples of dysfunctions of language-control processing in AD can be found within the grammatical competence literature. Emery (1982, 1985) examined syntactic deficits in AD and normal ageing. She administered a series of syntactic abilities tests to a sample of participants with AD and to age-matched and younger healthy controls. Emery found a gradual drop in performance on the Boston Diagnostic Aphasia Exam from pre-middle age to old age and a dramatic decline in performance in the participants with AD. The participants with AD were least impaired at the phonological level (which tests the ability to repeat sounds and words), and significantly more impaired at the morphological level (which tests comprehension of oral spelling). Emery also found that AD affected the ability to comprehend passivizations and prepositions. Emery concluded that the pattern of degeneration was the reverse of the pattern of syntactic development in childhood, such that the last of the linguistic functions to develop are the first to decline. Well-learned, automatic syntactic forms endure for longer in AD; in contrast, the syntactic forms that require non-automatic processing are likely to be the first to become unavailable. Kemper (1997) examined the ability to detect simple syntactic violations. She found that as tasks made greater demands on working memory, the detection of syntactic anomaly declined in people with AD. Kemper concluded that grammatical processes relying most heavily on the working memory system are those most affected by ageing and particularly AD.

Self-awareness deficits in AD are also related to language-control processes. Loebel, Dager, Berg and Hyde (1990) found that participants who were less fluent speakers were more aware of their memory impairments, while the more fluent speakers were less aware of their memory deficits. One plausible interpretation of these results is that people with AD who are aware of their cognitive decline choose to say less to avoid making errors. Further evidence of a metalinguistic impairment in AD comes from studies of speech monitoring and repair. People with mild to moderate AD corrected only 24% of their speech errors compared with 92% by age-matched controls (McNamara, Obler, Au, Durso, & Albert, 1992).

Papagno (2001) found figurative language was unaffected in the very early stages of AD, although impairments became apparent as the disease progressed. Participants with AD made more attempts to find the meaning of metaphors than they did for idioms, which Papagno attributed to the presence of semantic cues in metaphors. The comprehension of metaphors involves an active search of the specific semantic attributes of the words involved, and if these attributes can be accessed then comprehension is easier. In contrast, the meaning of idioms cannot be determined from their component words; instead its meaning is part of one's general knowledge. The loss of figurative speech in AD therefore reflects in part an inability to manipulate language.

We have shown then that there is good reason to suppose that the processes that control language are disrupted by AD. Astell and Harley (2002) suggested that people with AD are sometimes impaired on word definition tasks because of a metalinguistic impairment. They found that although people with AD could produce some definitions of animate and inanimate items, the quality of their definitions was quite poor. Surprisingly, all three participant groups (age matched controls, younger adults and people with AD) provided better definitions for low-frequency, atypical words than they did for high-frequency, typical items. This finding is counter to previous proposals that people with AD lose low-frequency atypical items first. Despite producing definitions that were categorised as inadequate, the definitions of participants with AD nevertheless contained some relevant information about the target. Astell and Harley claimed the inability to produce the necessary requirements of a formal definition reflects not only a breakdown in language processing but also a breakdown in metalinguistic skill.

Our current study uses a word definition task to examine the extent to which metalinguistic function is affected by probable AD.

What makes a good definition? Good definitions adopt a common format based on an idealised form of definition called *Aristotelian* (Litowitz, 1977; Snow, 1990). Aristotelian definitions usually include a superordinate and a restrictive complement (e.g. “an island is a body of land surrounded by water”). In order to be able to provide a good definition, a speaker must know the appropriate category to which a word belongs and know the concept’s distinguishable characteristics (Marinellie & Johnson, 2002). A good definition must be informative and complete (Watson, 1985), yet it must not be over-informative. The speaker has to know not to give redundant information (e.g. “a tiger is a big cat with stripes and is an animal with teeth”). The formation of a good definition needs metalinguistic knowledge: it requires an awareness of how to use language - particularly the knowledge of how to define. Furthermore, Litowitz (1977) found that adults who are able to define using the Aristotelian form can choose to produce definitions using lower-level categories or functional characteristics in situations where formal definitions are not required (e.g. defining a word to a friend). This adjustment of language to accommodate the listener’s needs is an important metalinguistic skill (Bialystok & Ryan, 1985).

The development of definitional skills is a measure of metalinguistic accomplishment in children (Snow, 1990). Children in the early stages of linguistic development provide definitions that are highly personal (including references to themselves or their experiences), concrete and functional (Benelli, 1988). As the child grows older they start to use superordinate category terms (Watson, 1995). The 6-7 year old child can readily generate superordinate information about some words (e.g. that a cat is an animal), but find generating more sophisticated superordinate categories (e.g. vehicle or utensil) much more difficult, requiring several years of experience and education before such terms can be used readily (Snow, 1990). Despite not using superordinate categories in the early stages of their language development, children can understand them. Benelli (1988) and Watson (1985) found children who never used superordinate categories such as "animal" could nevertheless respond correctly to questions such as "is a dog an animal?" Snow (1990) argued that the use of superordinate categories depends on knowledge of definitional forms – a skill that is not available in the early stages of cognitive development.

Any means of improving metalinguistic awareness improves definitional skills, including explicit schooling. DeBaryshe and Whitehurst (1986) argued that the rehearsal of language allows more adult-like definitions to develop in children. They proposed the use of taxonomic categories and their relationships is a consequence of "intra-verbal learning", whereby people learn about language through using language. As a consequence of the development of metalinguistic skills, children's definitions become more adult-like.

Clearly then defining a word contains a large element of metalinguistic skill. The purpose of this research is to identify if metalinguistic function is affected by AD. The widespread damage of moderate AD must lead to an impairment of the routes that support the executive processes underpinning metalinguistic processing, and therefore people with AD will have restricted metalinguistic ability. As a result, people with AD will find producing formal definitions difficult.

We expect that the performance of people with AD will share features of children in a pre-metalinguistic stage of language development. We expect fewer superordinate, taxonomic elements (e.g. “a dog is an animal”), perceptual elements (e.g. “a pig has a curly tail”), and functional elements (e.g. “a kettle is used to boil water”). We also predict that people with AD will produce more associative and personal elements (e.g. “I like horses” or “I just bought a new cooker”). Our most important prediction, however, is that although AD disrupts metalinguistic processing, the relevant semantic information need not also be lost. Hence people with AD will reveal knowledge under questioning that they do not produce spontaneously.

We also take this opportunity to examine differences in definitions for animate and inanimate objects. The pattern of performance on naming living and non-living things in people with AD is complex (Harley & Grant, 2004), but little is known at all about corresponding pattern of performance in the definitions task.

Experiment 1 generated a set of normative definitions of 32 words to be used in the main study. Experiment 2 tested our participants’ ability to define and name these items, and then whether they still knew information they did not provide in their spontaneous definitions.

Experiment 1

Generation of materials

Introduction

In this experiment healthy young adults generated definitions of 32 target words. These definitions were then used to generate high- and low-frequency definitional elements. The elements were then used to devise a set of open- and forced-choice questions to test the knowledge of participants with AD in Experiment 2.

Method

Participants

Ten participants generated our sample of definitions. All of the participants were aged between 18 and 57 and matched in years of education to the participants in Experiments 2 and 3. None of the participants suffered from AD or any other neurological disease.

Materials

The target stimuli were 16 animate and 16 inanimate words taken from Harley and Grant (2004). The pictures were matched as far as possible for name agreement, familiarity, and visual complexity. See Appendix 1 for the list of words.

Procedure

Participants wrote a formal definition of each of the 32 target words. They were told that their definition should enable someone who did not know the word to be able to identify it from their descriptions. Participants were tested individually and were given as much time as they needed; no one took longer than 45 minutes.

Results and discussion

We divided each definition into definitional elements. We scored each definition for the number of elements produced and for the frequency of mention of individual elements across participants. The highest frequency of mention of a definitional element was 10 (e.g. all 10 participants stated that a frog is green), and the lowest 3.

The words varied in the amount of agreement demonstrated by participants. For example, only 6 definitional elements were provided in total for “tractor” with very little agreement between participants. In contrast, 19 definitional elements were generated for the word “frog” with very high agreement. We used the elements with the highest agreement and frequency of mention to generate a set of forced-choice (e.g. “is a frog green?”) and open-choice questions (e.g. “”what colour are frogs?).

Experiment 2

Word-definition and picture-naming

Method

Participants

Seven people with AD took part in this experiment (5 males and 2 females). The mean age of the people with AD participants was 78.3 years (SD = 4.7), with a mean of 11.6 years of formal education (SD = 1.3). Neurologists confirmed all of the participants' clinical diagnosis of AD using examinations and evaluations from the Work Group of the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's disease and Related Disorders Association (ADRDA: McKahnn, Drachman, Folstein, Katzman, Price & Stadlan, 1984). The participants showed no signs of vascular dementia. The mean score of the participants with AD was 18.17 (SD = 5.5, range 9 to 25) on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), showing that our participants fell in the mild-to-moderate range of cognitive decline.

The control group comprised seven healthy older adults (HOA). Their mean age of was 80.0 (SD = 3.6), with a mean of 12.0 years of formal education (SD = 2.0); they were all female. The mean MMSE score for the HOA participants was 28.14 (SD = 1.1; range 26 to 29).

Participant information data is summarised in Table 1.

Insert Table 1 about here

The HOA and AD groups were matched for age (Mann-Whitney U = 19.00, N1 = 7, N2 = 7, p = 0.535, two-tailed) and years of education (U = 22.00, N1 = 7, N2 = 7, p = 0.805, two-tailed). There was, unsurprisingly, a significant difference between the participant groups' MMSE scores (U = 0, N1 = 7, N2 = 7, p = 0.001, two-tailed).

Materials

The stimuli for the definitions task comprised 16 animate and 16 inanimate words taken from Harley and Grant (2004), as used in Experiment 1. For each there were six questions comprising three open-choice questions (e.g. “what do chickens lay?”) and three forced-choice questions (e.g. “do we eat chickens?”), also as described in Experiment 1.

For the naming task, we used pictures of most of these items. The stimuli comprised twenty-nine pictures from Snodgrass and Vanderwart’s (1980) standardised black-and-white line drawings and an artist drew, in the same style as the Snodgrass and Vanderwart corpus, a picture of a ladybird. Two of the inanimate items do not appear in the Snodgrass and Vanderwart set (*tractor* and *washing machine*), and producing these pictures in the style of the Snodgrass and Vanderwart corpus proved too difficult. The pictures were presented on 6” x 6” white cards, with the pictures centred on the card and enlarged to font size 72.

Procedure

The participants were told that they were going to hear some words and instructed to describe the word’s meaning so that someone who had never heard or seen the word before could identify the item from their description. The participants were then given a practice word and were asked to define this word. They were then told that they would also be asked some questions about the word they were defining.

The words were presented verbally, one at a time and in a random order. Once the participant produced their definition they were asked “Is that everything you would like to say about -?” When they indicated their definition was complete they were then asked three forced-choice and three open-choice questions about the word they had just defined, in a random order.

The participants with AD were tested in three sessions, and the HOA participants in two sessions, over a three-week period. Each session took under 40 minutes. All of the participants took part in a follow-up session two weeks later. In this session all of the participants were tested to see if they could identify the correct word from their own definitions.

Two independent judges scored every definition produced by both groups. They rated the definitions as *adequate* or *inadequate*. A third judge made the final decision if there was disagreement between the judges. The same two judges also identified definitional elements in the definitions generated by the participants and assigned each of these to the categories of *taxonomic*, *perceptual*, *functional*, *associative* or *other*. When there was disagreement between the judges the third judge made the final decision. The judges were not told whether they were judging the definitions of someone with AD or someone from the control group.

The participants named the 30 pictures after they had finished the word definitions task. The pictures were presented sequentially in a random order. The task took approximately five minutes to complete.

Results and Discussion

The general level of definitional ability of the participants with AD was poor. They provided fewer definitional elements and less adequate definitions for both animate and inanimate words than the HOA participants.

Quantity of definitional material produced for both animate and inanimate words

The amount of definitional material produced by both groups is summarised in Table 2. We carried out two Kruskall-Wallis tests in order to identify any affect of group (HOA & AD) on animacy (total number of definitional elements produced for animate & inanimate words). We found a significant effect of group on total number of definitional elements produced for animate words ($\chi^2 = 9.036$, df = 1, $p < 0.005$) and inanimate words ($\chi^2 = 8.656$, df = 1, $p < 0.005$). Both groups produced more definitional elements for animate items compared with inanimate items (for the AD participants, Wilcoxon signed-ranks test z = 2.37, N – ties =7, $p < 0.02$, two-tailed; for the HOA participants, Wilcoxon signed-ranks test z = 2.37, N – ties =7, $p < 0.02$, two-tailed).

Insert Table 2 about here

Adequacy of definitional material for both animate and inanimate words

The adequacy of the definitions for each group is summarised in Table 3. We carried out a 2 x 2 mixed ANOVA, with two levels of group (HOA and AD) and two levels of word type (inanimate and animate), on the number of adequate definitions produced. Again there was a significant main effect of group ($F (1, 12) = 49.23$, $p < 0.001$), but here there was no effect of word type ($F (1, 12) = 0.055$, $p > 0.05$) and no interaction ($F (1, 12) = 0.219$, $p > 0.05$). Mann-Whitney tests revealed significant differences between the levels of adequacy of the HOA and AD groups for their definitions of both animate (U = 0.0, $N_1 = 7$, $N_2 = 7$, $p = 0.001$) and inanimate words (U = 0.0, $N_1 = 7$, $N_2 = 7$, $p = 0.001$).

Insert Table 3 about here

Detailed analysis of definitional elements for inanimate words

We carried out a 2 x 5 mixed ANOVA, with two levels of group (HOA and AD) and five levels of type of element (taxonomic, perceptual, functional, associative and other), on the number of definitional elements produced for words denoting inanimate things. The ANOVA revealed a significant main effect of group ($F(1,12) = 19.77$, $p < 0.001$) and of type of definitional element ($F(4, 33.15) = 12.26$, $p < 0.001$). There was a significant interaction between group and element type ($F(4, 33.15) = 5.04$, $p < 0.01$). In summary, the participants with AD produced fewer taxonomic, perceptual, functional, and other types of definitional element for inanimate items than the HOA participants. Importantly, as predicted, the interaction reveals that participants with AD produced more personal and associative elements and fewer taxonomic elements (see Figure 1).

Insert Figure 1 about here

Analysis of definitional elements for animate words

A similar 2 x 5 mixed ANOVA on the number of elements produced for words denoting animate things revealed a significant main effect of group ($F(1,12) = 22.439$, $p < 0.001$) and of definitional element type ($F(4, 25.08) = 9.15$, $p < 0.001$). There was no significant interaction between group and definitional element type ($F(4, 25.08) = 1.808$, $p > 0.05$). The results are broadly similar as for inanimate words (see Figure 2). However, Figures 1 and 2 show that the participants with AD were better at producing taxonomic and perceptual elements for animate words than they were for inanimate words.

Insert Figure 2 about here

So far we have found that the AD definitions are inadequate in ways we predicted on the basis of impaired metalinguistic ability. We now explore whether participants can supply information they did not provide in their definitions.

Evidence of preserved definitional knowledge not spontaneously produced

Can the participants with AD correctly answer questions about material that they do not produce spontaneously in their definitions? The percentages of each type of question answered correctly by each group is shown in Table 4.

Insert Table 4 about here

A Mann-Whitney test showed that the participants with AD answered significantly fewer questions correctly than the HOA participants ($U = 0.0$, $N_1 = 7$, $N_2 = 7$, $p = 0.001$). The key finding, however, is that the participants with AD could indeed supply a great deal of information that they did not offer in their spontaneous definitions. If we restrict the analysis to just the inadequate definitions produced by the AD group, the participants still got 46.9% of the open-choice questions and 85.5% of the forced-choice questions correct. Therefore the poor definitions cannot arise as a consequence of the loss of semantic knowledge alone.

Did the participants with AD simply make successful guesses? The magnitude of the effect makes this most unlikely. The AD group on average got over half the open-choice questions correct – an extraordinarily high level of performance. Although the performance of the AD group was variable (range correct 8.4% to 86.3%), even the lowest-scoring participant with AD knew information that they did not provide in their spontaneous definitions. Furthermore, 5 out of the 7 participants with AD got over half the open-choice questions right.

We analysed the responses to the forced-choice questions to ensure that the hit rate was above chance. A simple analysis shows that the participants with AD got on average 84% of the questions correct when the chance rate is 50%. A Wilcoxon Signed-Ranks Test showed that the number of times the participants with AD appropriately responded with "no" answers was significantly greater than the number of times they inappropriately responded with "yes" answers ($z = 2.232$, N – Ties = 6, $p = 0.026$, two-tailed). The calculation of the odds ratio revealed that the participants with AD were 3.7 times more likely to make an appropriate "no" response than they were to make an inappropriate "yes" response. Likewise, the number of times the participants with AD appropriately responded with "yes" answers was significantly greater than the number of times they inappropriately responded with "no" answers ($z = 2.384$, N – Ties = 7, $p = 0.017$, two-tailed). The calculation of the odds ratio revealed that the participants with AD were 5.9 times more likely to make an appropriate "yes" response than they were to make an inappropriate "no" response. These findings show that the AD group's responses reflect informed choices and not guessing.

Effects of severity

Although we are considering just small numbers of participants here, it is worth considering how the severity of AD affects performance. The more severe AD participants (n = 2) had MMSE scores of 9 and 15, and the less severe AD participants (n = 5) had MMSE scores between 19 and 25. The more severe AD participants produced no adequate definitions and the less severe AD participants produced a mean of 7.0 (SD = 4.1) adequate definitions. For, the inanimate items, the more severe AD participants produced a mean of 22.0 (SD = 5.6) and the less severe participants a mean of 30.4 (SD = 0.1) definitional elements. For the animate items, the more severe AD participants produced a mean of 33.0 (SD = 2.7) definitional elements, and the less severe participants produced a mean of 45.0 (SD = 5.4) definitional elements.

On the forced-choice/open-ended question component of the definitions experiment the more severe AD participants answered a total mean of 103.0 (SD = 55.2) questions correctly and the less severe participants answered a total mean of 141.6 (SD = 33.1) questions correctly.

Picture Naming

All of the HOA participants named all of the pictures correctly. The naming performance of the AD group was relatively good; they named a mean number of 24.0 (SD = 5.9) pictures correctly (ranging from 40% to 96.7% correct.). The difference in naming performance between the two groups was significant (Mann-Whitney U = 0.0, $N_1 = 7$, $N_2 = 7$, $p = 0.001$).

In the AD group, there was no significant difference in naming performance for animate and inanimate items. The participants with AD correctly named a mean of 12.6 animate pictures

(SD = 3.2) and 12.0 (SD = 2.9) inanimate pictures ($z = 0.966$, N – Ties = 5, $p = 0.334$, two-tailed).

Naming in response to self-generated definitions

The participants with AD correctly identified a mean of 6.6 (SD = 6.2) target words from their own definitions; the corresponding figure for the HOA participants was 27.9 (SD = 5.6). A Mann-Whitney test showed that difference between the two groups was significant ($U = 0.5$, $N_1 = 7$, $N_2 = 7$, $p = 0.001$). There was no relationship between the number of associative definitional elements produced in the AD participants' definitions and the subsequent likelihood of the participants being able to identify the target word from their own definition for animate ($\tau = 0.00$, $N = 7$, $p > 0.05$, two-tailed) or inanimate ($\tau = 0.205$, $N = 7$, $p > 0.05$, two-tailed) items. Exactly why some people with AD could identify the target words from their own definitions when others could not is worthy of further investigation. It is possible that when people with AD successfully identified the target from one of their own, inadequate definitions they relied on the presence of particularly notable personal information. For example, here is an example of a definition generated by someone with AD and rated "inadequate" by judges, but which enabled the participant to identify the target word two weeks later:

"We used to have one. We had a man out to butcher it. People used to have them hanging on their ceiling. They called them hams; they are cured and kept for a long time".

Qualitative analyses

Only one out of the seven participants with AD could name the picture of a ladybird. Only one participant answered most of the questions about the ladybird correctly and none of the participants could provide a formal definition of a ladybird. Participants produced definitions such as “a beautiful bird with green and blue feathers” or “a bird with brown spots”. These difficulties might arise because “ladybird” also has few close semantic neighbours few, if any, functions and only two principal perceptual features (*red* and *black spots*).

There was evidence of tip-of-the-tongue states in some of the participants with AD. For example, when asked the definition of a television, one person with AD said “I know what it is, it is a tele..f, it is a tele.., you know, one of those you know”.

Other participants with AD made semantic errors such as naming the zebra as a horse or naming the goat as a dog. One participant described a tractor as “like a train”. Other people in the AD group digressed from the focus of the task. One participant offered the following definition of a horse: “You can win a lot of money on them”, but then went on to tell a long story about a bet he once made. Such observations further suggest that people with AD have difficulty remembering the demands of the task and fail not just because of a lack semantic knowledge but because of lack of metalinguistic knowledge.

General discussion

Our results show that people with probable AD suffer from a metalinguistic impairment in addition to any loss of semantic knowledge. Our participants with AD were able to answer correctly open-choice and forced-choice questions pertaining to definitional information they did not provide spontaneously. Hence semantic degradation by itself cannot explain our participants' poor definitional performance.

The definitions of our AD participants were poor because they tended not to produce the appropriate taxonomic information (the superordinate category of the word to be defined) and instead produced too much associative (e.g. personal) information. Our data show that much of the information was nevertheless still available to the participants. Both of these failings arise from failures of non-automatic processing. We argue that our participants failed to produce sufficient taxonomic information because they have lost the metalinguistic knowledge about what constitutes a good definition. In many respects our participants with AD behaved like young children who have yet to master the metalinguistic skills with which to organise their knowledge and are therefore unable to produce sophisticated definitions. However, just like our AD group, although young children fail to make use of super-order categories in their definitions, they can answer questions indicating that they have knowledge of the information that they omit.

We also found that the participants with AD used more associative and personal information in their definitions than did the HOA participants. We suggest that this finding also reflects a decline in controlled processing. Poor inhibitory control is often characteristic of AD (Spieler, Balota & Faust, 1996) and also, to a lesser extent, normal ageing (e.g. Arbuckle & Gold, 1993; Hasher, Stoltzfus, Zacks, & Rympa, 1991; Mayr, 2001). This increased production of associative elements is also suggestive of poor metalinguistic functioning. A good definition must be informative, but also requires the speaker to have an awareness of what the listener needs to know. An adult with good metalinguistic competence will make judgements about how to define a word. For example, as we noted in the introduction, in situations where a formal definition is required the adult will choose an Aristotelian form; however when speaking to a friend, where formal definitions are not required, the adult will use lower-level categories or functional characteristics (Litowitz, 1977). The ability to make this judgement relies on metalinguistic information and the ability to model the knowledge of the listener. The AD group's increased use of personal information suggests a breakdown in these types of skill.

We also found that differences in the ability to define animate and inanimate items, although as ever, the pattern of effects was complex. Generally participants performed better with the animate items. Participants with AD are particularly poor at taxonomic (superordinate) information for members of inanimate categories. Categories such as "furniture" or "utensil" are more sophisticated and taught to children in school much later than categories such as "animal" (Snow, 1990).

In summary, we have shown that people with AD can sometimes access semantic information that they at first sight appear to have lost. They do not always offer this information spontaneously because of a metalinguistic problem associated with a lack of executive control and caused by disruption to the frontal pathways resulting from cortical atrophy. This finding has obvious implications for the treatment and quality of life of people with AD; rather than assuming material is lost, it is prudent to try a different task – or a different approach to the same task – to access knowledge in case it is spared. Of course, the sample size is relatively small and some caution in extrapolating the results necessary, but it is clear that we cannot assume that people with AD do not know simply because they do not tell.

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Note

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Appendix 1

Target words

Animate Words

Ant

Cat

Chicken

Frog

Goat

Horse

Monkey

Rat

Robin

Salmon

Elephant

Dog

Zebra

Pig

Fly

Ladybird

Inanimate Words

Doll

Television

Clock

Kettle

Sock

Ball

Bed

Chair

Glove

Iron

Kite

Piano

Stove

Knife

Tractor (not used in Experiment 2) 2)

Washing Machine (not used in Experiment

Table 1. Summary of participant data.

Participants	*Age*	*MMSE*	*Years education*	*Picture naming*
HOA				
NB	75	29	11	30
MSH	79	28	14	30
MSG	81	29	11	30
JM	82	29	14	30
LC	86	29	14	30
MJ	77	28	9	30
WB	80	26	11	30
AD				
GP	80	15	11	24
JM	71	9	11	12
SJ	81	19	12	29
MRG	74	20	12	29
JA	82	25	11	28
MM	70	22	10	26
AM	82	21	14	24

Table 2. Mean number of definitional elements produced by AD and HOA groups for animate and inanimate targets.

	Number of definitional elements for animate words	Number of definitional elements for inanimate words
AD Group	41.6 (SD 14.8)	28.0 (SD 11.2)
HOA Group	97.4 (SD 25.6)	67.6 (SD 20.7)

Table 3. Comparison of mean adequacy judgements for definitions of animate and inanimate words (out of 16).

Group	Animate	Inanimate
AD	2.4 (SD 2.7)	2.6 (SD 2.4)
HOA	13.4 (SD 3.0)	13.0 (SD 3.9)

Table 4. Percentage number of open-choice and forced-choice questions answered correctly for each group.

	Open-choice questions	Forced-choice questions
AD	51.4	84
HOA	100	100

Figure legends

Figure 1. Comparison of types of definitional elements generated for inanimate items

Figure 2. Comparison of types of definitional elements generated for animate items