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Tip-of-the-Tongue States and Lexical Access in Dementia

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We induced tip-of-the-tongue (TOT) states in elderly participants with probable Alzheimer's disease (AD). We found that they experienced TOTs but, unlike control subjects, were unable to provide any information about the target word for which they were searching. The related words produced by the AD participants were almost all semantically related to the target, with very few phonological relatives. (Adults normally produce more phonological relatives than semantic.) We examine the relationship between the target and non-target words produced in terms of their syntactic category, frequency, and imageability. The results are discussed with regard to their implications for speech production models. We interpret the results in terms of a two-stage interactive account where the retrieval deficit in dementia lies between the semantic and lexical levels.

The tip-of-the-tongue (TOT) experience has been much studied in young adults. Brown and McNeill (1966) induced TOTs experimentally by presenting subjects with definitions of rare words. They found that words produced in a TOT state were primarily phonological relatives of the target, with a smaller number of semantic relatives. Young adults are often able to provide information about the number of syllables, syllabic stress, the initial letter or phoneme of the target word, and sometimes other segments as well (Brown & McNeill, 1966; Koriat & Lieblich, 1974; Lovelace, 1987; Rubin, 1975; Yarmey, 1973; see Brown, 1991, for a review).

The study of TOTs sheds light on the processes of word selection and retrieval, both components of *lexicalization* in speech production. There are two major theoretical questions to be answered about the origin of TOTs, which can be summarized as, *where* and *why* do TOTs occur? Most current models of speech production posit two stages of lexicalization (Harley & MacAndrew, 1992; Kempen & Huijbers, 1983; Levelt, Schriefers, Vorberg, Meyers, Pechmann, & Havinga, 1991). The semantic specification is used to retrieve an abstract lexical item (or *lemma*), which is then used to retrieve the detailed phonological form of the word. When TOTs are induced experimentally, the definition provides the semantic specification from which the lemma is selected. One plausible explanation of TOTs in the two-stage model is that the target lemma is successfully activated by the semantic specification, but that phonological-form retrieval then fails, or is only partly successful. This leads to the subjective feeling of knowing the word, accounts for the higher incidence of phonological neighbors relative to semantic neighbors of the target (as they will receive spreading activation from the target lemmas), and explains the partial availability of phonological and structural information. There is insufficient activation, however, to activate the full phonological form of the target. Burke, MacKay, Worthley, and Wade (1991) propose an alternative account based upon what may be seen as a version of a one stage model of lexical access: in their model the semantic and phonological systems are directly connected. Hence are TOTs best explained in terms of a one- or two-stage model of lexicalization? There are also two main theories of the origin of TOTs. The *transmission deficit* or *insufficient activation* hypothesis states that target items do not receive sufficient activation to be retrieved, with word frequency, recency, and aging contributing to the probability of this occurring (Burke et al., 1991; Meyer & Bock, 1992). The *competition* or *blocking* hypothesis is that similar items block or inhibit the access of the target (Jones & Langford, 1987).

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TOTs occur more frequently with age. Elderly subjects are more likely than young or mid-age adults to recall little or no phonological information about the target word (Burke, Worthley, & Martin, 1988; Burke et al., 1991; Cohen & Faulkner, 1986; Maylor, 1990). They are less likely than younger adults to produce alternative words and are more likely to give up pursuing the target (Burke et al., 1991; Cohen & Faulkner, 1986). It is possible to account for these findings with the two-stage model of lexicalization. The different characteristics of older adults' TOTs suggest that with increasing age their occurrence is not simply a failure at the word form stage. Instead this breakdown may be combined with difficulties elsewhere in the system, or it may happen earlier in the process, possibly in accessing the lemma.

There is also evidence that the lemma stage of lexicalization is affected in patients with probable Alzheimer's disease (AD). Speech disturbance is a noted feature of this illness (Alzheimer, 1907). Problems with naming are particularly evident (Bayles, 1982; Bayles & Tomoeda, 1983; Bayles, Tomoeda, & Trosset, 1990; Cummings, Benson, Hill, & Read, 1985; Hodges, Salmon, & Butters, 1991, 1992; Kirshner, Webb and Kelley, 1984; Martin & Fedio, 1983; Shuttleworth & Huber, 1988) and in retrieval ability in general (Miller, 1979; see Hart, 1988, for a review). Evidence from confrontation naming tasks suggests that a breakdown occurs in the semantic-to-lexical mapping of speech (Bayles, 1982; Bayles & Tomoeda, 1983; Henderson, Mack, Freed, Kempler, & Andersen, 1990; Hier, Hagenlocker, & Shindler, 1985). One reason could be that the semantic specification is compromised (Chertkow & Bub, 1990a,b; Hodges et al., 1991, 1992). Alternatively, Miller (1979) argued that the disinhibition of plausible alternatives (in this case, related words), proposed by Warrington and Weiskrantz (1970) to explain word retrieval difficulties of amnesics, leads to a decline in retrieval ability in dementia. On this view the retrieval and production of the target word depends, in part, on the successful inhibition of rivals, and an increase in disinhibition contributes to retrieval difficulties. There are similarities here with the blocking hypothesis of Jones and Langford (1987), although they do not discuss failure to inhibit as a causal mechanism in TOTs. The inhibition hypothesis finds further support from selective attention tasks that suggest that decreased efficiency of inhibitory mechanisms follows with increasing age (Hasher, Stoltzfus, Zacks, & Rypma, 1991). This disinhibition explanation also fits well into connectionist two-stage accounts of lexicalization where within-level inhibition is an important processing mechanism (Harley & MacAndrew, 1992; Stemberger, 1985).

We use the verbal definition design of R. Brown and McNeill (1966) to induce TOT states in individuals with AD and age-matched controls. As our main concern is speech production, we analyse spoken responses. The majority of studies that use TOT to investigate retrieval processes have used a written response format. Such methodology has produced TOT rates of 13% (Brown & McNeill, 1966), 20% (Jones & Langford, 1987), and 23% (Perfect & Hanley, 1992) in young adults. These figures reflect so-called *subjective TOT* experiences (Jones & Langford, 1987), which are whenever subjects indicate that they are in a TOT state. Contained within these are a subset, named *objective TOTs,* in which subjects can provide partial information about the target and do not give any incorrect information. The proportion of responses that were objective TOTs in previous experiments were only 3.5% (Jones & Langford, 1987) and 4.5% (Perfect & Hanley, 1992). The most likely explanation for the high proportion of subjective TOTs is that when written responses are required subjects record TOT states when they just feel that they know the word, and do not necessarily reflect lexical access. Thus subjective TOTs may be another name for so-called feeling-of-knowing responses in other studies (Maylor, 1990; Yaniv & Meyer, 1987). By recording verbal responses we hope to more easily distinguish true TOTs from subjects feeling that they know, or should know, a word. We use higher frequency target words than Brown and McNeill, as naming studies have shown poor performance by dementing patients on low frequency items (Kirshner et al., 1984; Skelton-Robinson & Jones, 1984).

If normal aging mechanisms are exacerbated, difficulties should arise in accessing the lemmas rather than phonological forms, and hence we predict that individuals with AD will, like older subjects, have a higher incidence of TOT states than control subjects. They will be able to provide little or no phonological information about the targets, and that few related words will be produced. Those which are should be semantic rather than phonological relatives of the target.

TOTs should also provide information on whether the impairment of semantic memory in dementia occurs as a result of a difficulty in accessing knowledge, or of a loss of that information (Nebes, 1989). If semantic knowledge has been lost, then in TOT states AD subjects should have preferentially preserved knowledge of superordinate information relative to subordinate, should show a disproportionate loss of information about low frequency items, and, in as much as loss of facilitation by priming reflects the inability to activate partial information, they should be generally poor at producing related competitors to the target (Chertkow & Bub, 1990a,b; Hodges, Salmon, & Butters (1991, 1992); Warrington & Shallice, 1984). Furthermore, studying TOTs in individuals with AD should contribute to knowledge about the processes involved in normal lexicalization, by providing an account that can also deal with abnormal production.

METHOD

Subjects

The experimental group of 12 subjects comprised 10 females and 2 males, with a mean age of 81:11 (range 75:8 to 88:3 years, standard deviation 3.74). Their mean years of formal education were 10.08 (range 9 to 12 years, standard deviation 1.44). Each had a diagnosis of probable Alzheimer's disease (AD), by the criteria developed by 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) (McKhann et al., 1984), and all had Hachinski Ischemic scores of four or less (Hachinski et al., 1975). Nine of the subjects were tested on the 30-point Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975) producing a mean of 15, range 8–22. The other three members of this group were assessed on the Clifton Assessment Procedure for the Elderly (Pattie & Gilleard, 1979) and were classified as High or Maximum dependency.

The control group comprised 12 volunteer adults, 9 female and 3 male, all living unsupported in their own homes in the community. Their ages ranged between 72:0 and 84:0 with a mean age of 78 (standard deviation 3.93). Their years of formal education ranged between 9 and 15, with a mean of 10.16 years (standard deviation 1.89).

Materials

The 24 words used are listed in Appendix A. According to Kučera and Francis (1982), 12 were high frequency words, each occurring more than 25 times per million (mean 49), and 12 were low frequency, occurring fewer than 10 times per million (mean 3.5).

Procedure

Both groups were given the definitions to read, revealed one at a time. If a participant was unable or unwilling to do this the experimenter read them out. They were usually read at least twice, in a random order. Subjects' verbal responses were recorded manually. All the control subjects completed the task in one session of approximately 10 min. Some of the AD participants found the task very demanding and completed the task over two sessions.

If the subject produced a word in answer to the definition, it was recorded and the next definition was given. Sometimes subjects immediately said that they did not know the answer and on some trials subjects offered irrelevant information as a response to the definition. A subject was deemed to be in a TOT state only if they indicated that they knew the word but were unable to retrieve it, and if they carried out an active search in an attempt to locate the target word. These were often marked by phrases such as "it's on my tongue" and "I can't get my tongue round it." They were then asked to give any information they could about the target for which they were searching. All subjects in a TOT state that was unresolved within 3 min were given the opportunity to have a second attempt if they wished following presentation of all the definitions. When a subject failed to produce a response or if they were in an unresolved TOT state, the target word was supplied. When given the target word, subjects either spontaneously confirmed or were asked to confirm if the word supplied was the word that matched the definition and for those subjects experiencing TOT states, if this was the word for which they were searching.

The semantic relationship between target and responses was judged by 14 independent raters. In addition a control pool of 40 word pairs was generated by randomly pairing target words with responses from this and similar unreported experiments. Raters assigned word pairs a value between zero and four using the following criteria: (1) no link: the meanings of the words are completely unrelated; (2) far-fetched link: the meanings of the words are related in some way; (3) weak link: the meanings of the words are slightly related in some way; (4) strong link: the meanings of the words are fairly closely related in some way; (0) where the meaning of one or both of the words is unknown. A mean rating of 1.5 or more was taken as indicating that the words are semantically related in some way (see Appendix B for mean ratings).

RESULTS

Responses were classified into five categories: First, a "don't know" or no response at all; second, the correct production of the target word; and third, a TOT state, which might eventually be resolved (or not) to the satisfaction of the participant. In some TOT states participants produced words as an attempt at the target; we call these *relatives* of the target. The fourth category comprises words produced by subjects as what they considered to be the appropriate response to the definition. This group will be called *own-target words* to distinguish them from the target words of the experimenter. The fifth category we call *constructive search* items, where subjects either made guesses at the target or embarked on a constructive search for the target word: these responses are distinct from TOT states in that subjects knew that the words were not the ones that fit the definition, but at the same time they were not in a TOT state. TOT, own-target words, and constructive search responses are termed non-target responses, and only the "don't know" responses are considered incorrect and therefore not analysed further. We compare the relationship in frequency, imageability (where there are enough items to enable a meaningful analysis), phonology, syntactic category, and semantic relationship between the target and responses for each of these categories, as these factors are known to be important in word substitutions

TABLE 1
Comparison of Responses Made by Control and AD Group, by Absolute Number, and Percentage

Response type	Control group	AD group
Correct target word	230 (80%)	129 (46%)
Don't know	1 (0.5%)	42 (14%)
Resolved TOT	9 (3%)	20 (7%)
Unresolved TOT	7 (2.5%)	16 (5%)
Own-target word	17 (6%)	41 (14%)
Constructive search	24 (8%)	40 (14%)

in normal speakers (Harley & MacAndrew, 1995). The imageability of items was compared using ratings taken from the Oxford Psycholinguistic Database (Quinlan, 1992), which is a composite value arrived at by blending ratings from the Paivio (1968), Toglia and Battig (1970), and Gilhooly and Logie (1980) norms.

Overall Comparison of AD and Control Groups

Over the 288 definitions, the control group made 230 (80%) correct responses to the target and the dementia group 129 (46%), with means of 19.17 (range 16–22) for control subjects and 10.75 (range 4–19) for experimental subjects (see Table 1). This difference is significant ($t[22] = 6.839$, $p < .001$). The dementia group also made significantly more "don't know" responses or no response at all, with means of .08 for the control group and 3.50 for the dementia group ($t[22] = 4.01$, $p < .001$). Looking at all valid responses, that is, all trials upon which a response was attempted, the 36 TOTs of the dementia group comprised a significantly higher proportion than the 16 TOTs of the control group ($\chi^2(1, N = 533) = 12.35, p < .001$). The dementia group responses are more evenly distributed across the response categories. Hence, as predicted, the dementia group were poorer at lexical retrieval and made more TOTs.

TOT Data

All of the control group TOTs were induced by low frequency items. There was a significant difference in the degree to which high and low frequency items induced TOT states in the AD group ($t[22] = 5.09$; $p < .001$), with a mean number of TOTs of 2.33 for low frequency items and .583 for high frequency items. There was a significant difference in imageability between words that induced TOTs and those that did not ($t[15] = 2.81$, $p < .05$), with those targets that did being lower in imageability (mean = 5.60) than those that did not (mean = 5.99). (It should be noted that there was no significant correlation between frequency and imageability in the target words,

TABLE 2
Mean Frequency and Imageability Ratings for the Target and Non-Target Response Words

	Mean frequency	Mean imageability		Mean frequency	Mean imageability
			AD group		
Target	11.09	*	TOT word	13.70	*
Target	12.37	*	Own-target	36.15	*
Target	18.35	5.77	Search	39.41	5.62
			Control group		
Target	3.29	*	TOT word	9.00	*
Target	12.82	*	Own-target	7.27	*
Target	12.44	5.56	Search	25.61	5.49

* Too few word pairs with imageability ratings.

$r_p[14] = +.42$, although this is marginal). The AD group could not report any partial phonological information about the targets they had in mind.

TOT Relatives

Relatives of the target words were produced in TOT states by both groups. This happened with 9 of the 16 control TOTs, producing 11 relatives, and in 18 of the 36 AD group TOTs, producing 33 relatives. Two of these were non-words (see Appendix B). Table 2 shows the mean frequency of the targets and the words that came to mind in a TOT state. The mean was calculated using only the pairs where both members have a frequency rating of at least 1 per million.

The relatives produced by both groups while in a TOT state did not differ significantly in frequency from the targets (AD $t(22) = .41, p > .5$; control $t(6) = .91, p < .1$). All of the target and relative words were nouns.

All of the control group targets and relatives, and 30 of the 31 word relatives produced by the dementia group, were semantically related on the basis of our judging task. The semantically unrelated word, *ottoman*, was judged to be a phonological relative of the target, *octopus*, according the criteria of Jones and Langford (1987) of shared initial letter and number of syllables. The t-tests further confirmed that the TOT relatives were semantically related to the target compared with the random word pairs ratings in both the control ($t[49] = 18.2, p < .001$) and AD ($t[69] = 17.96, p < .001$) groups. There was no significant difference between the two groups ($t[40] = .99, p > .3$).

The nature of the semantic relationship between target and relative was explored using the semantic category norms of Battig and Montague (1969). In the AD group all but one of the relatives were category co-ordinates of the target, and the one instance of a superordinate category name (*snake* for *octopus*) might also be best interpreted in this way. The semantically related words produced by the control group were all category coordinates of the targets.

Own-target Words

Table 2 shows the mean frequencies for target and own-target words. There was no difference between the frequencies for either group (AD, $t[26] = 1.13, p > .1$; control, $t[10] = .78, p > .1$). All of the control group own target words were singular nouns. Of the 41 own-target words produced by the AD subjects 34 were nouns, 5 were noun phrases, 1 was a proper noun and 1 was an adjective. In addition, five of the nouns were pluralized, whereas the targets were all singular nouns.

Two of the AD own-target words had ratings below 1.5 (see Appendix C), while all of the control group ones were judged to have a semantic relationship. Both the control ($t[55] = 36.67, p < .001$) and AD ($t[79] = 14.06, p < .001$) own-targets were more semantically related to the targets than chance, but there was a significant difference between the two groups ($t[56] = 3.05, p < .005$), with the AD group being less related.

The AD group did not produce any superordinate category labels as own target words although the noun phrases "enthusiastic worker" (for *botanist*), "greedy animal" (for *turkey*) and "big fish" (for *octopus*) could be interpreted as this. Among the control group's own-target words there was one category subordinate.

Constructive Search Words

These are words produced by subjects as they actively searched for the response to the definition, but were not so sure of the target word that they felt themselves to be in a TOT state. The AD group made constructive search responses 62 times over 40 trials and phrases, and the control group made 28 responses over 24 trials. The words produced by the AD group while actively searching for an answer to the definition were higher in frequency than the target words ($t[45] = 2.20, p < .05$); this difference was not found in the control group between targets and constructive search words ($t[17] = .78, p > .1$). There was no significant difference between the target and search words on imageability for either group (AD, $t[19] = 1.12, p > .1$; control, $t[8] = 0.29, p > .5$). The AD group search words were 58 nouns, 1 noun phrase, 1 adjective, and 2 gerunds. All of the control group search words were nouns, with one pluralized.

Three of the 62 AD group search words were judged to be not semantically related to their targets, while all of the control ones had a semantic relationship (see Appendix D). Both control ($t[66] = 37.78, p < .001$) and AD ($t[100] = 13.60, p < .001$) groups were semantically related, although again the AD group search items were less related than the controls ($t[88] = 4.16$, $p < .001$). The AD group produced two superordinate category terms.

DISCUSSION

Our most salient finding is that the AD group was poorer at lexical retrieval, giving fewer correct answers and having more TOT states in response to definitions than their age-matched controls. TOTs are more likely to occur on low frequency, low imageability targets. Items produced in TOT states by the AD group tend to be semantically related to the target, but not as closely as those produced by the controls. Relatives were largely category coordinates rather than super-ordinates. Words are syntactically related to the target, but again less so than the controls. Hence there is a gradation such that although words produced in TOT states were related to the target in both groups, the constraints are less effective in AD patients.

TOT states accounted for 5.5% of control group responses and 12% of the AD groups. If we take objective TOTs to be the true equivalent of verbal TOTs in written-response studies, we can compare our findings to the 3.5% of Jones and Langford (1987) and 4.5% of Perfect and Hanley (1992) with young adults. Thus our results accord with the noted feature that older adults experience more TOT states than younger adults (Burke et al., 1988, 1991). When they felt they should know a word but were sure that it was not on the tip-of-the-tongue, constructive search responses were produced. We propose that these responses are recorded as TOT states in many written-response tasks. Thus, objective TOTs provide a more accurate record, in written-response tasks, of TOT experiences. We have captured true TOT states using spoken responses, and this has enabled the separation of responses into different categories. This supports the view of Kohn et al. (1987) that spoken responses more accurately reflect the naturally occurring TOT state.

The relatives produced by both groups while in a TOT state did not differ significantly in frequency from the target words. Similarly, the targets and relatives tended to be from the same syntactic categories and were usually semantically related. Analysis of the own-target words revealed similar characteristics. The lack of frequency effects in the TOT relatives and own target words and the large proportion of category coordinates among these do not support the suggestion that semantic knowledge is lost (Chertkow & Bub, 1990a,b; Hodges et al., 1991, 1992). These findings suggest either that it is temporarily inaccessible so that semantic competitors cannot be distinguished or that semantic relatives with similar specifications are not successfully inhibited.

As noted above our constructive search responses strongly resemble feeling-of-knowing responses reported in other studies. Participants actively search to find the correct answer, offering suggestions as they pursue the

target. This process can be likened to the *generation-recognition,* or *extrinsic-cueing,* identified by Jones (1978). This, his second route to retrieval, is based on the generation of words related to the target using extrinsic knowledge. The words produced whilst making a constructive search by the AD group were significantly higher in frequency than the targets while the control group search words were not. This difference in frequency may be associated with the AD subjects carrying out the generation process out loud. For instance, one participant when searching for the target *geography* generated a list of school subjects. The control group constructive search responses were mostly one word followed by them apparently rethinking and then offering another. The occurrence of constructive search responses, combined with clear ''don't know'' responses, support the notion that monitoring of cognitive processes is retained not just in the early stages of AD (Bäckman & Lipinska, 1993), but also as the disease process becomes quite advanced.

Across all response types, most were syntactically and semantically related to the targets, but less so for the AD than the control groups. Such semantic and syntactic similarity mirrors the pattern found in normal speech errors and reflects the operation of multiple constraints as in word substitutions in normal spontaneous speech (Harley, 1984, 1988). We take this as evidence for the view that the process of spreading activation and most of the units from which activation originates must both be preserved. However, that the constraints operate less strongly than in the control group, as evinced by the weakened semantic and syntactic constraints, suggests that the links along which activation spreads are weakened. This accords with the simulations of Harley and MacAndrew (1992), who proposed that aphasic naming difficulties result from weakened connections.

In older adults, fewer relatives and less phonological information about the target are produced. The AD group offered even less phonological relatives of the target. This supports the idea that with increasing age TOTs are attributable to a different failure in the lexicalization process than that which causes them in younger subjects. We proposed that in younger subjects TOTs are attributable to a failure between the lexical and phonological levels following successful access of the lemma stage.

This shift in pattern suggests that in older adults the lemma stage is not completed successfully and this leads to TOT states, as the target lexical item receives insufficient activation to become output. The semantic specification activates related lemmas and sends activation down to their respective phonological forms. The target lemma does not receive sufficient activation, as opposed to the target *phonological* representation in younger adults. In this case the relatives will be semantically rather than phonologically related to the target. If this shift is accentuated in dementing subjects, or if the connections are further weakened, then even less phonological information will be retrieved. Low frequency, low imageability items are particularly susceptible to loss as their activation levels will be lower. This finding is further evidence that two stages are needed to account for lexicalization phenomena, and our results are consistent with the insufficient activation theory of origin.

Positing that the failure occurs at the lemma stage has a variety of implications depending on exactly how the breakdown occurs. Three possible explanations are possible in the two-stage lexicalization model. The first is that the links between the semantic and lexical levels weaken and eventually become lost. Second, that semantic units in the system are lost. As both of these would lead to insufficient activation arriving at the target lexical item, we have decomposed the insufficient activation hypothesis into two. Third, that the within-level inhibitory links between competing items become weakened and eventually lost. This would lead to phonological blocking between competitors. We interpret our results as primarily supporting the weakened semantic-to-lexical connections version of the insufficient activation hypothesis, although the greater number of own-target and "don't know" responses in the AD group suggests that loss of units might also occur, particularly in the severest patients.

APPENDIX A

Target Words and Definitions with Frequencies (per Million, in Parentheses)

High Frequency	
butter (27)	An edible fat made from churned cream which you use spread on bread
brush (36)	Thing made of bristles set in wood used for hair, shoes or fingernails
chair (89)	A piece of furniture for sitting on at a table
cup (58)	A piece of china for drinking tea out of
egg (47)	It has a yolk and a white and is laid by birds
garage (25)	A building for keeping cars in
gold (37)	Yellow-coloured precious metal used for jewellery
library (90)	Building from which to borrow books
snake (70)	Reptile with no legs and a forked tongue that slithers about
tie (27)	Item of clothing worn knotted around a shirt collar
uncle (58)	Your father or mother's brother
watch (31)	Time-piece that is worn on the wrist
Low Frequency	
antler (3)	The large spiky horn of a stag or other deer
barber (5)	Man who cuts hair and gives shaves
botanist (3)	A person who scientifically studies plants
carrot (5)	Long orange vegetable that grows under the ground
geography (5)	Study of the earth which uses maps and is taught in schools

APPENDIX A—*Continued*

glacier (2)	Slow-moving mass of ice found at the tops of mountains
mermaid (1)	Woman who lives in the sea and has a fish's tail
octopus (1)	A sea creature with eight tentacles
owl (6)	Large-eyed bird of prey that flies at night and hoots
raft (5)	A boat made from pieces of wood tied together
turkey (4)	A farmyard animal that gobbles and is eaten at Christmas
wizard (3)	A male witch who is said to perform magic, sorcery and conjuring

APPENDIX B

AD and Control Groups' Target Word and TOT Relative Pairs, and Random Target and Response Control Word Pairs, with Mean Semantic Relatedness Ratings (Figure in Parentheses Indicates How Many Times This Response Was Given; Default Is Once)

AD Subjects' Responses	
antler–horn (2)	3.50
antler–reindeer	3.71
barber–hairdresser	3.86
botanist–farmer	2.07
botanist–gardener	3.64
botanist–geologist	2.50
botanist–ornithologist	2.64
carrot–cauliflower	3.57
carrot–potato	3.29
garage–shed	3.50
glacier–iceberg	3.93
glacier–icicles (2)	3.21
octopus–crab	3.43
octopus–crocodile (2)	2.64
octopus–lizard	2.21
octopus–ottoman	1.13
octopus–octopan	nonword
octopus–octoped	nonword
octopus–snake	2.57
owl–cuckoo (2)	3.29
owl–hawk	2.93
raft–paddle	3.14
raft–plank	2.21
uncle–brother-in-law	3.43
uncle–father-in-law	3.00
uncle–mother-in-law	3.00

APPENDIX B—*Continued*

uncle–sister-in-law	3.00
wizard–ghost	2.14
wizard–witch	3.64
Control Subjects' Responses	
botanist–agriculturalist	2.92
botanist–biologist	3.14
botanist–entomologist	2.60
botanist–florist	2.64
geography–atlas	3.71
glacier–iceberg	3.93
mermaid–maid	2.00
raft–float	3.57
wizard–magician	3.79
wizard–merlin	3.86
wizard–warlock	3.54
Random Word Pairs	
snake–loofah	1.15
trousers–bag	1.50
chair–worm	1.21
banjo–apple	1.00
octopus–actor	1.00
steak–greenhouse	1.07
barge–parsnip	1.00
train–horseshoe	1.00
bear–drum	1.21
gold–eagle	2.21
uncle–lorry	1.00
turkey–umbrella	1.00
dress–rock	1.00
wizard–saxophone	1.00
road–cockerel	1.14
raft–deer	1.07
wheelbarrow–pig	1.35
spade–animal	1.21
van–rafter	1.00
wardrobe–conjuror	1.28
table–omnibus	1.00
strawbery–coins	1.00
crab–bicycle	1.00
antler–paddle	1.07

APPENDIX B—*Continued*

bath–scientist	1.07
violin–swing	1.07
crown–whistle	1.00
trombone–goat	1.00
mermaid–pheasant	1.00
spade–wolf	1.00
recorder–turban	1.00
trumpet–face	1.07
hammock–sampan	1.33
turban–dragonfly	1.00
bath–ambulance	1.14
owl–pencil	1.00
geography–pigeon	1.07
cap–pelmet	1.21
botanist–scissors	1.07
apron–worm	1.00

APPENDIX C

AD and Control Groups' Target Word and Own-Target Word Pairs with Mean Semantic Relatedness Ratings (Figure in Parentheses Indicates How Many Times This Response Was Given)

AD Group	
antler–porcupine	1.50
barber–enthusiastic worker	1.71
barber–hairdresser	3.86
botanist–gardener (4)	3.64
botanist–scientist	3.57
butter–margarine (2)	3.86
carrot–marrow	3.50
carrot–potato	3.29
carrot–spuds	3.36
garage–parking place	3.21
geography–areas	3.43
geography–maps	3.79
glacier–frozen	3.14
glacier–iceberg (2)	3.93
glacier–rocks	3.21
gold–platinum	3.64
gold–silver	3.64
mermaid–sailor's wife	2.15
mermaid–swimmer	2.86

APPENDIX C—*Continued*

octopus–lobster	3.21
octopus–big fish	2.86
owl–swans	3.07
raft–fishing-boat	3.14
raft–rafter	2.15
raft–risky	1.07
snake–fish	2.57
tie–pullover	3.14
tie–scarf	3.58
tie–terylene	1.64
turkey–goose	3.29
turkey–greedy animal	1.93
uncle–William	1.50
uncle–stepfather	3.14
wizard–bitch	1.21
wizard–comedian	2.29
wizard–conjuror	3.79
Control Group	
barber–hairdresser (2)	3.86
botanist–gardener (4)	3.64
botanist–horticulturalist (2)	3.60
butter–cheese	3.79
glacier–iceberg (2)	3.93
snake–adder	3.93
tie–shirt	3.21
turkey–goose	3.29
uncle–in-law	2.86
wizard–conjuror	3.79
wizard–magician	3.79

APPENDIX D

AD and Control Groups' Target Word and Constructive Search Word Pairs with Mean Semantic Relatedness Ratings (Figure in Parentheses Indicates How Many Times This Response Was Given)

AD Group	
antler–animal	3.14
antler–cavalier	1.21
antler–collars	1.64
antler–crown	2.29
antler–elephant	2.21

APPENDIX D—*Continued*

antler–feathers	1.71
antler–fur	2.07
barber–farmer	1.64
botanist–gardener	3.64
botanist–head gardener	3.71
botanist–specialist	3.07
brush–grease	1.86
brush–oil	1.93
butter–cheese (2)	3.79
butter–crumbs	2.64
butter–fats	3.29
butter–jam	3.21
butter–lard	3.86
butter–meaty	1.14
butter–spread	3.64
butter–tomatoes	2.50
carrot–apple	3.14
chair–cushion	3.54
cup–coffee-pot	3.21
cup–teapot	3.57
cup–wineglass	3.71
geography–arithmetic	3.00
geography–composition	1.93
geography–history	3.07
geography–map-finding	3.07
geography–map-reading	3.14
geography–teacher	3.57
glacier–iceberg	3.93
glacier–temperature	2.64
glacier–weather	2.21
gold–bracelets	3.12
gold–brass	3.57
gold–carats	4.00
gold–ring (2)	3.43
owl–cuckoo	3.29
owl–dove	3.21
owl–eagle	3.50
raft–barge	3.21
snake–worm	3.07
turkey–chickens	3.21
turkey–cockerels	3.29
turkey–dog	2.14

APPENDIX D—*Continued*

turkey–goose	3.29
turkey–mincemeat	2.21
turkey–mistletoe	2.14
turkey–mouse	2.21
turkey–rat	2.14
uncle–cousin	3.57
uncle–relative (2)	3.71
watch–clock	3.86
wizard–actor (2)	1.71
wizard–actress	1.36
wizard–gentleman	1.86
Control Group	
barber–hairdresser	3.86
butter–cheese (2)	3.79
butter–yoghurt	3.14
carrot–marrow	3.50
carrot–parsnip	3.50
carrot–potato (2)	3.29
carrot–swede	3.57
carrot–turnip	3.43
geography–archaeology	2.64
geography–globe	3.64
geography–history	3.07
glacier–iceberg (3)	3.93
glacier–ice-floe	3.71
glacier–icicles	3.07
raft–canoe	3.43
raft–catamaran	3.32
raft–sampan	3.60
tie–scarf (2)	3.58
turkey–goose (2)	3.29
uncle–nephew	3.71
wizard–conjuror	3.79
wizard–magician	3.79

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