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Resolving Tip-of-the-Tongue States in Young and Older Adults: The Role of Phonology

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Abstract

Tip-of-the-tongue (TOT) states occur when a word is temporarily inaccessible for retrieval, despite a feeling of knowing the word. TOTs occur for people of all ages, but are particularly frustrating for older adults, most likely because TOTs increase across the lifespan and therefore become more noticeable to older adults, both in naturalistic and laboratory studies. One explanation for this increase is the Transmission Deficit model, where older adults have greater difficulty activating the necessary phonology, i.e., sounds, to facilitate word retrieval (e.g., Burke, MacKay, Worthley, & Wade, 1991). The present chapter reviews studies on the role of phonology in both inducing and resolving TOTs and presents new data from 327 young adults and 132 older adults that categorizes TOTs on two dimensions: (1) the percent of “know” responses, “TOT” responses, and “don’t know” responses that occur following a definition-like general knowledge question, and (2) the most common alternative words that come to mind instead of the to-be-retrieved word. Norms of this type do not exist for either young or older adults, and this chapter helps to identify stimuli that are most effective at inducing and resolving TOTs in both age groups.

Resolving Tip-of-the-Tongue States in Young and Older Adults: The Role of Phonology

The tip-of-the-tongue (TOT) experience is a phenomenon that refers to a type of word retrieval failure, where a word is known but cannot be produced at a particular time (R. Brown & McNeill, 1966). Even when the word itself cannot be retrieved, people often have access to some phonological information about the word. Specifically, people can sometimes report the initial letter or sound, the first syllable, the final letter, number of syllables, and stress pattern (e.g., R. Brown & McNeill, 1966; Burke, MacKay, Worthley, & Wade, 1991; Harley & Bown, 1998; Koriat & Lieblich, 1975; Miozzo & Caramazza, 1997; Rubin, 1975). The importance of phonology in causing TOTs has been documented theoretically in the Transmission Deficit model (e.g., Burke et al., 1991; Burke & Shafto, 2004; James & Burke, 2000; MacKay & Burke, 1990; Rastle & Burke, 1996), which proposes that TOTs occur when connections to a word's phonological nodes are weakened and transmit insufficient priming to enable activation and retrieval of the word. These connections to phonology weaken as a function of two factors, frequency and recency of use; as a result, TOTs typically occur for low-frequency words and words not used recently (e.g., Burke et al., 1991; Vitevitch & Sommers, 2003). The Transmission Deficit model can also explain the availability of phonological information during TOTs, which occurs when some of the phonological nodes receive enough priming to become activated. However, *all* phonological nodes must become activated for the entire word to be retrieved.

A third factor that reduces connection strength and transmission of priming is the normal aging process, resulting in older adults having more TOTs both in the laboratory and in everyday life (e.g., Brown & Nix, 1996; Burke et al., 1991; Cohen & Faulkner, 1986; Cross & Burke, 2004; Evrard, 2002; Heine, Ober, & Shenaut, 1999; Maylor, 1990b). This increase in TOTs is

accompanied by a decrease in availability of phonological information: Compared to young adults, older adults report less phonological information about the target word (e.g., Burke et al., 1991; Cohen & Faulkner, 1986; Heine et al., 1999). Older adults also are less likely to have an alternate word in mind when in a TOT state (e.g., Burke et al., 1991). These alternates, referred to as blockers (Reason & Lucas, 1984), interlopers (Jones, 1989), or persistent alternates (Burke et al., 1991), refer to an incorrect word that involuntarily comes to mind, instead of the intended word, and these alternates often overlap in phonology with the TOT word. Older adults' inability to retrieve partial phonological information and alternates to the same degree as young adults suggests that older adults have greater difficulty activating the necessary phonology to facilitate word retrieval (e.g., Burke et al., 1991; James & Burke, 2000).

Under the Transmission Deficit model's assumption that weakened connections to phonology cause TOTs, strengthening these connections should reduce TOTs and facilitate word retrieval as well as help resolve TOTs, both in young and older adults. This idea has been tested in two ways: (1) presenting a word's phonology prior to inducing a TOT and then assessing the incidence of a TOT for that word, or (2) presenting a word's phonology after a TOT has occurred and measuring whether the TOT word can now be retrieved.

Presenting Phonology Before Inducing TOTs

The general methodology in these studies involves presentation of a word(s) phonologically related to the target word (i.e., words that contain some of the target's phonology, such as the first phoneme, first syllable, stress pattern, or number of syllables), followed by a definition-like, general knowledge question intended to elicit retrieval of the target. If less TOTs are reported following phonologically related words relative to unrelated words, then this result would support the Transmission Deficit model's claim that recent presentation of a word

phonologically related to the target strengthens phonological connections to the target, facilitating its retrieval. Only a few studies have been conducted solely with young adults, and these have led to mixed results. Bowles and Poon (1985) found that phonologically related words increased word retrieval and therefore reduced TOTs, relative to unrelated words, whereas Jones (1989) showed that phonologically related words decreased word retrieval and increased TOTs (but see Meyer & Bock, 1992, and Perfect & Hanley, 1992, for critiques on Jones' stimuli).

Research with both young and older adults has demonstrated support for the Transmission Deficit model. Rastle and Burke (1996) exposed participants to a target's phonology by having them complete a pronunciation task, where a list of words was shown one at a time, and participants read each word aloud. Following a ten-minute delay, participants heard a list of definitions corresponding to targets and were asked whether they knew the word, did not know the word, or were having a TOT. Half of the targets corresponding to the definitions had been presented during the pronunciation task, while the other half were words not seen recently. They found that more correct retrievals and fewer TOTs were experienced following words presented in the pronunciation task relative to nonpresented words, and this reduction in TOTs was equivalent for both young and older adults.

James and Burke (2000, Experiment 1) presented the target's phonology within the context of different words. They asked participants to read words aloud that cumulatively contained all of the syllables of the target word. For example, if participants had a TOT for the target word *abdicate*, they read aloud primes that included the following words: abstract, indigent, truncate, tradition, and locate. They then saw the general knowledge question and attempted to retrieve the target. Prior production of the target's phonology via phonologically related words increased correct retrieval of targets and reduced TOTs. Similar to Rastle and

Burke (1996), young and older adults benefited similarly from prior presentation of the to-be-retrieved phonology.

Recently, Burke, Locantore, Austin, and Chae (2004) investigated retrieval of proper names in young and older adults using homophones, words that sound the same but are spelled differently, to present a target's phonology in the prior production task. Using fill-in-the-blank statements, participants named either homophones (e.g., pit) or words phonologically unrelated to the target and then attempted to name a picture of a famous person whose name corresponded to the other spelling of the homophone (e.g., Brad Pitt). Prior production of the homophone increased retrieval of the proper names and reduced TOTs; however, this facilitation occurred only for older adults, not young adults. Their explanation for this age difference lies in the increased difficulty of retrieving proper names relative to object names. Within the Transmission Deficit model, proper names have virtually no connections to nodes in the semantic system, which makes them vulnerable to deficits in the transmission of priming to their lexical nodes and corresponding phonological nodes. For example, the proper name "Pitt" has no semantic connections except to the full name of people possessing that name, such as "Brad Pitt". In contrast, the object name "pit" connects to its many semantic properties, where "holds seed", "found in fruit", and "is hard" represent only a few of these properties. Although retrieving proper names is more difficult than retrieving object names for both young and older adults, this difficulty is exacerbated in older adults because of their weakened connections, resulting in more TOTs for proper names (e.g., Burke et al., 1991; Evrard, 2002). However, older adults are therefore able to benefit more than young adults from the strengthening of connections caused by production of the homophone, as found in Burke et al. (2004).

Presenting Phonology After TOTs Have Occurred

Measuring the influence of phonology after a TOT has occurred has been tested using both cueing and priming paradigms. In both types of studies, the general knowledge question is presented first, and participants are asked to indicate whether they know, don't know, or are having a TOT for the target, which is the question's answer. Words phonologically related to the target are then presented, and participants are again presented with the question and asked to retrieve the target. The logic is that presenting the general knowledge question first can induce TOTs; therefore, presentation of a word's phonology in this methodology addresses whether phonology facilitates word retrieval by resolving TOTs.¹ The fundamental difference between cueing and priming paradigms is that in cueing paradigms, participants may be aware that the phonologically related words are related to the target word. This awareness of the relation between the cues and the target could cause participants to use a directed memory search for the target, using the cue's phonological properties. In contrast, priming studies present phonologically related words in a context where the words are seemingly "unrelated" to the general knowledge questions. Priming studies more closely reflect the spontaneous resolution processes that occur in everyday life, where the TOT word seems to "pop" into mind without conscious effort (see James & Burke, 2000, for further discussion of cueing vs. priming).

Studies on resolving TOTs in young adults have shown that both phonological cues and primes typically increase TOT resolution: Word retrieval is more likely to occur if words or letters that share phonology with the target word are presented during a TOT state (e.g., Abrams, White, & Eitel, 2003; Meyer & Bock, 1992). However, Abrams and Rodriguez (2004) found that a phonological prime's syntactic class determined the effect on TOT resolution. Participants read

¹A few studies (Jones, 1989; Jones & Langford, 1987; Maylor, 1990a) do not explicitly ask participants whether or not they are experiencing a TOT before presenting the phonologically related words. Therefore, these studies cannot

general knowledge questions and indicated whether they knew, did not know, or were having a TOT for the target. Following “TOT” and “don’t know” responses, participants saw five words, four of which were phonologically unrelated filler words and one that was either a phonological prime or another phonologically unrelated filler. Phonological primes contained the target’s first syllable and either shared or did not share the target’s part of speech. For example, the target “rosary” (a noun) was primed either with “robust” (an adjective) or “robot” (a noun). Retrieval of the target was attempted again after presentation of the five-word list. Different part-of-speech primes facilitated resolution of TOTs and increased target retrieval relative to phonologically unrelated words, whereas same part-of-speech primes had no effect on TOT resolution.

The only evidence for an inhibitory effect, where phonologically related words increased TOTs, comes from Jones and his colleagues (e.g., Jones, 1989; Jones & Langford, 1987), but these studies have been criticized for improper counterbalancing that artificially inflated TOTs following phonologically related words (Meyer & Bock, 1992; Perfect & Hanley, 1992).

With respect to older adults, phonological cueing studies have also demonstrated mostly facilitation from phonologically related cues, although Maylor (1990a) demonstrated more TOTs following phonologically related cues relative to unrelated cues in 50 year-olds, similar to Jones (1989) and Jones and Langford (1987)’s studies with young adults. However, Maylor (1990a) found no effect of phonologically related words in 60 and 70 year-olds. Heine et al. (1999) found that cues consisting of the target’s first letter (as well as dashes to indicate word length) increased retrieval of targets relative to semantic cues (words related to the target in meaning) for college students, young-old adults (ages 60-74), and old-old adults (ages 80-92), with young-old

address TOT resolution and instead can only look at the occurrence of TOTs following phonologically related words.

adults having more facilitation relative to the other two age groups. Differences in older adults' retrieval as a function of phonological cues in the above studies above may be a function of the cueing paradigm. Older adults generally are less able to use conscious recollection strategies as effectively as young adults (e.g., Light & LaVoie, 1993), which suggests that cueing studies may adversely affect older adults' ability to consistently demonstrate either inhibition or facilitation from phonology (see also Burke et al., 2004).

Using phonological primes, several recent studies have demonstrated that both young and older adults have increased word retrieval following phonological primes presented during TOT states. James and Burke (2000, Experiment 2) presented general knowledge questions, and following retrieval failures, they asked participants to read aloud and rate the pronunciation difficulty of primes cumulatively containing the phonology of the target (see the earlier description of Experiment 1 for sample primes). Both young and older adults resolved more TOTs after pronouncing the phonologically related list relative to an unrelated list, and the size of this priming effect was equivalent in both age groups.

White and Abrams (2002) tested young adults and two groups of older adults, a young-old group (aged 60-72) and an old-old group (aged 73-83), using a phonological priming paradigm. After presentation of general knowledge questions, participants read primes that shared a single syllable with the target, either the first, middle, or last syllable. The results showed that resolution of TOTs was greater following first-syllable primes relative to unrelated words, and this increased word retrieval occurred for young and young-old adults, but not old-old adults.

In sum, the data from studies with phonological cues and primes suggest that exposure to phonology, both before and after a TOT experience, influences word retrieval (most often by

increasing it) in both young and older adults, although old-old adults are less likely to benefit to the same degree. These results support the Transmission Deficit model, where recent presentation of a word's phonology facilitates retrieval of the TOT word by transmitting bottom-up priming to other lexical nodes connected to it. Since the TOT word is connected phonologically to the related word, it accumulates enough priming to become activated and retrieved. Although older adults' connection strength is reduced, making them more susceptible to retrieval failures, the similarity between young and older adults in phonological priming of TOTs suggests that the benefits of activation through recent presentation are similar across age.

However, there are still a number of unanswered questions about characteristics inherent in the primes and targets that affect young and older adults' word retrieval and the degree to which young and older adults are differentially influenced by these characteristics. Several recent studies have begun to explore some of these factors. Vitevitch and Sommers (2003) found that both neighborhood density (the number of words that differ from a target by only one phoneme; see also Harley & Bown, 1998) and neighborhood frequency (the mean word frequency of all of a target's neighbors) influenced the occurrence of TOTs, with differential effects for young and older adults. Young adults had more TOTs for words with sparse neighborhoods than for words with dense neighborhoods, independent of neighborhood frequency. In contrast, older adults exhibited more TOTs for words with sparse neighborhoods only when the word had low neighborhood frequency.

With respect to phonological priming of TOT resolution, Abrams and Rodriguez (2004) showed that in young adults, a prime's word frequency was related to the likelihood of target retrieval following presentation of the prime. There were significant correlations between a prime's Francis and Kucera (1982) word frequency and the probability of resolving TOTs for its

corresponding target. For different part-of-speech primes, the correlation was positive such that TOT resolution increased when the phonological prime was higher in frequency. For some part-of-speech primes, the correlation was negative, where TOT resolution decreased as the phonological prime increased in frequency. Whether the same pattern emerges for older adults is an empirical question that has yet to be tested.

These studies illustrate that there are many other factors to be explored in research on TOTs and TOT resolution. The present study provides a set of stimuli to facilitate future research in these areas.

The Present Study

Despite age equivalence in phonological priming of word retrieval, young and older adults do not necessarily qualitatively experience TOTs in the same way. Using data from five experiments conducted by Abrams and her colleagues, the purposes of the present study were: (1) to distinguish the definitions that are effective at consistently inducing TOTs from those that do not regularly elicit TOTs, (2) to examine which words induce TOTs in young and older adults, and (3) to identify the words that come to mind as alternate words when the target is not retrieved. By examining a large number of young and older adults' responses, the present study provides a set of extensive stimuli, which is especially significant given that there are relatively few published studies of normative data from both young and older adults (e.g., see White & Abrams, in press). Our compilation of responses can be used to facilitate future studies with TOTs and phonologically related words by overcoming certain obstacles.

One issue in TOT research is that people experience TOTs on only a small number of trials, approximately 8-18% of the time (A. Brown, 1991). As a result, only a small percentage of the overall data can be analyzed, reducing the statistical power of the design (see Brown &

McNeill, 1966, and Burke et al., 1991, for a discussion of the data loss problem). For example, if 80 targets are used in a study, then participants will experience TOTs for only 10 targets, on average. There are several reasons why TOTs occur infrequently. Some target words may have been less susceptible to TOTs, either because they were too easy and participants knew the words, or because they were too difficult and participants did not contain these words and definitions in their vocabulary. Comparing young and older adults complicates this picture because older adults generally have more “know” responses and less “don’t know” responses than young adults (e.g., Burke et al., 1991; Vitevitch & Sommers, 2003; White & Abrams, 2002), which is most likely due to older adults’ larger vocabularies (e.g., Kemper & Sumner, 2001; Verhaeghen, 2003). Thus, TOT research is most likely comparing young and older adults’ responses on different stimuli. Another issue relevant to TOT research is that people sometimes experience TOTs for a word different from the target, usually a synonym, e.g., “kerchief” instead of “bandanna”. These TOTs are then categorized as incorrect TOTs and are excluded from analyses, resulting in even less data that can be analyzed.

A second issue involves alternate words, which we are defining as words that participants were either incorrectly thinking of upon hearing the definition or that came to mind when participants were unable to retrieve the intended word. Just as targets may differ in susceptibility to TOTs for young and older adults, the types of alternate words that come to mind may also have age differences. Whereas previous research has established that older adults are less likely to think of alternates during TOTs, no one has categorized the words that are produced by young and older adults or assessed whether certain TOTs are more likely to produce predictable alternates than others.

In consideration of the above issues, the present study compiled a list of targets, their

corresponding general knowledge questions, first-syllable primes, alternate words, and the percent of time young and older adults experienced TOTs on these targets. This list indicates targets on which words young and older adults had similar opportunities for TOTs as well as targets that were not effective for inducing TOTs in either or both age groups. These data can also be used to determine the general knowledge questions that should be modified to increase the likelihood of TOTs as well as the targets that should be excluded from use in future studies.

Method

Participants

Data from 327 young adults and 132 older adults were collected across five experiments. Table 1 presents each experiment and the age characteristics of its participants. Three experiments are with young adults only and come from Abrams et al. (2003) and Abrams and Rodriguez (2004), and two experiments tested both young and older adults; these come from White and Abrams (2002) and Robinson, Abrams, and Bahrick (2004).

Materials

All studies used definition-like questions to elicit TOTs for specified target words. Across studies, 163 different targets were tested, some of which were taken from previous studies (Burke et al., 1991; Francis & Kucera, 1982; Jones, 1989; Kohn et al., 1987; Meyer & Bock, 1992; Nelson & Narens, 1980) and others that were created by Abrams and her colleagues. All target words were 1-5 syllables in length, low frequency as measured by Francis and Kucera (1982), and none were proper names.

Primes consisted of either phonologically related words containing the target's first syllable (Abrams & Rodriguez, 2004; Abrams et al., 2003, Experiments 2 and 3; White & Abrams, 2002), middle or last syllable (White & Abrams, 2002), or first letter and/or phoneme

(Abrams et al., 2003, Experiments 1 and 3). Robinson et al. (2004) was not designed as a priming study and therefore did not include primes.

The appendix presents the general knowledge questions, corresponding targets, and up to five first-syllable primes used in four of the five experiments detailed here. For targets that shared the same first syllable (e.g., “abacus” and “abdicate”), only one set of primes is listed because primes can be used for both targets. As can be seen in this appendix, primes consisted of both high- and low-frequency words whenever possible. For example, for the target “affidavit”, “after” is a high-frequency prime (699 per million; Francis & Kucera, 1982), whereas “affable” is a low-frequency prime (1 per million; Francis & Kucera, 1982). Because researchers tend to use a variety of word frequency databases, we did not list frequency in the appendix; however, we refer the reader to available frequency databases (e.g., Baayen, Piepenbrock, & van Rijn, 1993; G. Brown, 1984; Francis & Kucera, 1982; Lund & Burgess, 1996; Thorndike & Lorge, 1944).

A few issues should be noted when selecting stimuli from this appendix. First, primes were designed to overlap in phonology with the target, but not necessarily orthography. For example, the target “acapella” had primes such as “octopus”, which shares sound but not spelling with the target. Second, the phonological overlap between a prime and target’s first syllable was assessed using Webster’s New World College Dictionary (Neufeldt & Guralnik, 1997). However, dictionaries can vary slightly in their phonetic descriptions, so future studies using these primes in conjunction with primes not listed here should verify all primes’ phonology using the same reference. Third, Abrams et al. (2003) showed that retrieval of targets whose first syllable comprised of a single letter, e.g., aorta, was not facilitated by primes that overlapped solely in first phoneme/letter. Therefore, most of these targets were later paired with primes that

also contained the second phoneme, e.g., “atrocit^y” was a prime for “atone”. However, some of the targets were not used in later studies and therefore do not have these modified primes; these exceptions are indicated in the appendix.

Procedure

All experiments used the same initial procedure, which involved presenting a general knowledge question on the computer screen, and participants were instructed to say “know” if they knew the word, “don’t know” if they did not know the word, or, “TOT” if they were having a TOT for the word. After responding “know,” participants stated the retrieved word, which may or may not have been the intended target. In all but one experiment (Robinson et al., 2004), after a “don’t know” or “TOT” response, phonological primes intermixed with unrelated words were displayed one word at a time², followed by the same general knowledge question. Participants again responded whether they knew, did not know, or were having a TOT. Participants who were still unable to retrieve the target were asked to state any other words that were in mind. After all questions had been presented, a recognition test was administered to determine whether or not the participant had experienced unresolved TOTs for the intended target. This test consisted of the questions for which the participant never retrieved an answer, along with four possible answers to choose from. Its purpose was to identify incorrect TOTs, corresponding to targets that were not identified correctly on the recognition test, so that they could be excluded from analyses relevant to each individual experiment.

Results

Responses to General Knowledge Questions

²As a control, some questions were followed by all phonologically unrelated words instead of primes.

Table 2 displays the means and standard deviations for the overall percent of “TOT”, “know”, and “don’t know” responses given by each age group following the first presentation of the general knowledge question. TOTs and “know” responses were further categorized as either correct or incorrect. Incorrect “know” responses occurred when participants retrieved a word other than the target after responding “know”. TOTs were categorized as incorrect when a word other than the target was retrieved following the priming manipulation or when the target was not chosen on the recognition test.³ T-tests were conducted on each type of response to assess age differences, and $p < .05$ was used as the criterion for significance in all analyses. Older adults overall exhibited more correct TOTs, more correct “know” responses, and fewer “don’t know” responses than young adults. For incorrect responses, young adults had more incorrect TOTs than older adults, whereas older adults had more incorrect “know” responses.

Table 3 lists the percent of time young and older adults responded “TOT”, “know”, or “don’t know” for each individual target. Note that there were 28 targets that were not used in the experiments with older adults, and these targets are indicated by a 0 in the number of participants column. There was considerable variability in targets’ capability for inducing TOTs, both for young and older adults, such that stimuli induced TOTs anywhere from 0% (for “numismatist”) to 47.9% (for “pawn”) of the time in young adults and 0% (for “amorous”) to 52.5% (for “planetarium”) in older adults. The table also illustrates variability between the age groups in inducing TOTs because young and older adults exhibited greater amounts of TOTs on different words. For example, “philatelist” induced correct TOTs in older adults 30.4% of the time, but only 9.3% of the time in young adults. Conversely, there were virtually no age differences for

³Robinson et al. (2004) did not use a method for identifying the correctness of TOTs, so we arbitrarily categorized all of them as correct TOTs, which slightly raises the ratio of correct TOTs to incorrect TOTs. This is justified by the finding that TOTs are more often correct than incorrect (e.g., White & Abrams, 2002).

“dowry”, which produced correct TOTs 25% of the time in young adults and 24.4% of the time in older adults.

We calculated the percent of targets on which young and older adults experienced correct TOTs at least 8% of the time (the lower end of the range of TOT rates reported by A. Brown, 1991). Young adults experienced TOTs on 71% of the targets, whereas older adults experienced TOTs on 86% of the targets. Similarly, 73% of the targets produced correct TOTs at least 8% of the time in *both* young and older adults, suggesting that the majority of general knowledge questions were useful in inducing TOTs in both age groups.

To identify general knowledge questions that were not specific enough in inducing retrieval of the intended target, we compared the percent of targets that yielded more incorrect responses than correct TOTs. Young and older adults had more incorrect “know” responses than correct TOTs for 43% and 42% of targets, respectively. Young adults experienced more incorrect TOTs than correct TOTs for 6% of targets, whereas older adults exhibited more incorrect TOTs on only 3% of targets. This relatively large number of incorrect responses given by both age groups suggests that many of the definitions were eliciting retrieval of a word different from the target.

Alternate Words Available During TOTs or Incorrectly Retrieved as Targets

Table 4 lists alternate words that were in mind during TOTs as well as alternates incorrectly retrieved as targets after a “know” response. It is important to clarify that unlike previous studies, the goal of the present study was not to determine the percent of time that alternates occurred in young and older adults during TOT states. Instead, we were interested in using alternates to see whether any consistencies existed between young and older adults in

retrieving a specific alternate. The top three alternates⁴ are listed along with the number of people who gave that response.⁵ A response was required to be given at least twice for inclusion in this table. Targets for which young and older adults gave the same most frequent alternate are marked with an asterisk. As can be seen in this table, there is remarkable similarity in the alternate words produced by young and older adults: young and older adults retrieved at least one of the same alternates 86% of time. However, both age groups retrieved the same most frequent alternate only 46% of the time, suggesting that there are age differences in the most available alternate. Alternates also shared phonological overlap with the target on some occasions, e.g., the alternate “scramble” shares /am/ with the target “anagram”, although the amount of overlap is not as high as reported in previous studies. This result most likely occurred because our alternates included words incorrectly retrieved following a “know” responses, which were most often synonyms that are not necessarily phonologically related to the target.

Discussion

The results of the present study support the idea that there are both similarities and differences in the types of words on which young and older adults experience TOTs. In terms of similarities, both age groups demonstrated that some targets elicit TOTs more than others. Furthermore, young and older adults had the same alternate word in mind 86% of the time among their top three alternates, suggesting that when alternate words were retrieved, young and older adults were retrieving similar types of words. This finding can be especially useful for phonological priming studies given the overlap of alternates and targets in phonology; some of

⁴If there was a tie for 3rd place, a 4th alternate word was listed.

⁵More young adults were tested than older adults, which yielded more opportunities for young adults to produce alternates.

these alternates could also serve as primes, and they have the advantage of being equivalently represented in young and older adults' lexicons.

With respect to age differences, approximately 25% targets did not result in a sufficient number of correct TOTs for both age groups. In looking at targets where only one age group had TOTs at least 8% of the time, this result typically occurred because older adults knew the answer or young adults did not know the answer, resulting in fewer TOTs for that age group. This finding suggests that some of the targets are differentially susceptible to TOTs as a function of age group; therefore, future research should consider using our tables to select targets that overall are more equivalent in inducing TOTs in young and older adults. Dahlgren (1998) has suggested that older adults have more TOTs because they have a greater base of knowledge (i.e., vocabulary). If TOT studies equate young and older adults by giving them relatively equivalent opportunities to experience TOTs, then finding that older adults still experience increased TOTs would contradict Dahlgren's (1998) conclusion (see Cross & Burke, 1994, and Heine et al., 1999, for other arguments against this conclusion). Nonetheless, the fact that older adults consistently display larger vocabularies than young adults (e.g., Kemper & Sumner, 2001; Verhaeghen, 2003) may explain why they have fewer incorrect TOTs relative to young adults. By virtue of their reduced vocabularies, young adults do not know as many of the targets as older adults. Therefore, young adults may be more likely to say "TOT" when not experiencing one to reduce the number of times they say "don't know", for fear of appearing less intelligent to the experimenter.

The tables presented here also demonstrate that independent of age, some of the general knowledge questions used in TOT studies need revision. Questions that rarely result in correct TOTs because the targets are easily retrieved (a high percent of correct "know" responses) or not

in participants' vocabulary (a high percent of "don't know" responses) may not be worth using, at least in their present form. Questions that elicit many incorrect responses (either "know" or TOT) should be modified to increase the likelihood that the target will be the to-be-retrieved word. Alternates can also provide significant information: Targets that have frequent alternates coming to mind indicate that the general knowledge questions are not precise enough to encourage retrieval of the intended target. Consideration of these factors will lead to a more useful set of general knowledge questions and targets.

Other factors besides the wording of the general knowledge question contribute to targets' susceptibility to TOTs and TOT resolution. A word's frequency influences TOTs, with more TOTs occurring for low-frequency words (e.g., Burke et al., 1991). A word's neighborhood density and neighborhood frequency interact with age to determine the rate of TOTs (Vitevitch & Sommers, 2003). A prime's part of speech in conjunction with a prime's word frequency influences TOT resolution following phonological priming (Abrams & Rodriguez, 2004). There are also individual differences in rates of TOTs; participants vary greatly in how many TOTs they experience and in the amount of phonological priming of TOT resolution. Using the data tabulated here to investigate new factors will extend our understanding of the role of phonology in lexical retrieval while overcoming some of the difficulties of conducting TOT research. Having more TOTs occur will decrease the variability that accompanies a small number of TOTs (e.g., Brown & McNeill, 1966; Burke et al., 1991). Most importantly, future studies will be able to assess potential age differences in TOTs and phonological priming of TOT resolution using an optimal set of stimuli.

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Appendix

General Knowledge Questions, Targets, and First-Syllable Primes

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call an instrument for performing calculations by sliding beads along rods or grooves?	abacus	abstinence	abnormal	abdomen	absence	abhor
What word means to formally renounce a throne?	abdicate	<i>See abacus</i>				
What is the musical term that means 'without instrumental accompaniment'?	acappella	occupancy	octopus	octagon		
What do you call a person who computes insurance risk and premiums?	actuary	acrobat	accurate	activated	acronym	acknowledgment
What is a sworn statement in writing, made under oath?	affidavit	affirmation	affluent	after	affable	
What do you call a solemn declaration made by a person who conscientiously declines taking an oath?	affirmation	<i>See affidavit</i>				
What do you call someone who believes that we cannot know whether or not God exists?	agnostic	agony	aggravate	agriculture		
What is a large seabird, sometimes used as a metaphor for spiritual burden?	albatross	alibi	allocate	alfalfa	albino	altruistic
What is a medieval chemical science concerned primarily with the conversion of the base metals into gold?	alchemy	<i>See albatross</i>				

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the term for a brownish-yellow fossil resin used for making jewelry and ornaments?	amber	ammunition	amphibian	amateur	amplify	amputate
What is the name of the substance derived from a whale that is used to make perfume?	ambergris	<i>See amber</i>				
What is the food of the Greek and Roman gods?	ambrosia	<i>See amber</i>				
What do you call a pardon for political offenses against a government?	amnesty	<i>See amber</i>				
What do you call being full of love or fond of loving?	amorous	<i>See amber</i>				
What word is used to describe something that exists or seems to exist outside of its proper time?	anachronistic	anonymous	anesthetize			
What is a word or phrase made from another word by rearranging its letters?	anagram	ancestor	annual	analyze	antenna	animate
What do you call someone who believes there should be no organized government?	anarchist	<i>See anagram</i>				
What do you call a short account of an incident (especially a biographical one)?	anecdote	<i>See anagram</i>				
What is the largest artery in the human body?	aorta ^a	able	agency	alien		
What do you call the study of the positions of celestial bodies with the belief that they have an influence on the course of natural earthly occurrences and human affairs?	astrology	assumption	assemble			

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the term for making amends for a sin?	atone	attenuate	atrocitiy			
What is the name for a large, bright colored handkerchief or square of material usually worn around the neck?	bandanna	bandit	banish	banner	banjo	
What do you call small, shelled animals which accumulate on the underside of a ship?	barnacles	bartender	barbaric	barbecue	bargain	
What word means to trade by exchanging goods for others' goods rather than money?	barter	<i>See barnacles</i>				
What is the name of the animal that builds canals or dams?	beaver	beacon	beyond			
What do you call an account of a person's life written, produced, or composed by another?	biography	biceps	bisect			
What is a flat, curved, wooden weapon which returns to the thrower?	boomerang	bootlegger	booty	booster		
What do you call a dead body used for dissection?	cadaver	colonial	canary	communicate	cathedral	<i>See also corona</i>
What is the medical symbol consisting of two snakes entwined on a winged rod?	caduceus	<i>See cadaver or corona</i>				
What is the process of adjusting a measuring instrument to a standard?	calibration	calcium	calendar	calorie	calculus	calculate
What do you call exercises that are designed to develop muscular tone and to promote physical well-being, and are performed without an apparatus (e.g., running)?	calisthenics	<i>See calibration</i>				

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call the art of elegant, highly decorative handwriting?	calligraphy	<i>See cadaver or corona</i>				
What term means to declare a deceased person a saint?	canonize	cancel	candid			
What do you call a tiny vessel that connects an artery and a vein?	capillary	capture	captain	capsule	captivate	
What do you call a substance that tends to cause a cancer?	carcinogen	cartilage	cardiac	carnation	carbohydrate	cartridge
What do you call a person who makes maps?	cartographer	<i>See carcinogen</i>				
What do you call a percussion instrument used especially by dancers that consists of two small shells of hard wood, ivory, or plastic?	castanets	cascade	casserole	castle		
In psychology, what is the term for a technique used to relieve tension and anxiety by bringing repressed feelings and fears to consciousness, i.e., a purging of emotions?	catharsis	<i>See cadaver or corona</i>				
What is a small lizard noted for its ability to change color to resemble its environment?	chameleon	<i>See cadaver or corona</i>				
What do you call a representation of a small angel, portrayed as a child with a chubby rosy face?	cherub	cherry	cherish			
What is the term for a usually prepared for possibility whose occurrence depends on chance or uncertain conditions?	contingency	conspiracy	conspicuous	consumer	conversion	conductive
What do you call illegal trade, or smuggling goods into or out of a country contrary to law?	contraband	consequence	contemplate	contact	connotation	conscious

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the outermost part of the sun's atmosphere called?	corona	comedian	cocoon	collection	commander	<i>See also cadaver</i>
What do you call a public officer whose primary function is to investigate by inquest any death thought to be of other than natural causes?	coroner	corsage	cordial			
What is the name for a person trained to pilot, navigate, or otherwise participate in the Soviet space program?	cosmonaut	costume	cosmetic			
What do you call a formal, binding agreement, or the word meaning the promises from God to humans?	covenant	cover	covet			
What is a stoppered glass vessel in which wine or liquor is brought to the table?	decanter	decision	defiant	deceptive	design	deteriorate
What is the term for violating the sanctity of a shrine or holy place?	desecrate	detriment	debtor			
What do you call someone who believes that there is no such thing as free will and that our fates are directed by forces that we cannot control?	determinist	<i>See decanter</i>				
What is the word that means to cause to explode or to set off, e.g., a bomb?	detonate	<i>See desecrate</i>				
What is the term for the money or property that a bride brings to her husband at marriage?	dowry	<i>No primes used</i>				
What do you call someone who is concerned only with him or herself, rather than the society?	egocentric ^a	edict	emu			

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call the three periods (...) used to indicate an omission or a pause?	ellipsis	electron	elongate	elastic		
What do you call the developing fetus before birth?	embryo	emperor	emphasize	empire	embassy	employ
What is the name of a green precious stone used in jewelry, such as necklaces or rings?	emerald	<i>See embryo</i>				
What word means to put into code or cipher?	encrypt	enhance	enzyme	entice	entire	
What is the term for writing one's signature on the reverse side of a check?	endorse	<i>See encrypt</i>				
What word means lasting only a very brief time?	ephemeral	<i>No primes used</i>				
What is the outermost layer of skin called?	epidermis	epic	epoch			
What do you call a closing section added to a novel providing further comment or information?	epilogue	<i>See epidermis</i>				
What is the word for someone who rides on horseback?	equestrian	equivalence	equivocal	equipment		
What do you call something that is intended for, or understood by, only a small group of people?	esoteric	escalator	espionage	estimate	escapade	
What do you call any of several hormones produced chiefly by the ovaries that act to regulate certain female reproductive functions?	estrogen	<i>See esoteric</i>				
What is a substitution of an inoffensive term for one considered offensive?	euphemism ^a	eulogy	euthanize	eucalyptus	euphoria	

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call a preacher of the gospel who holds large, often televised, public services?	evangelist	event	evict	evaporate		
What is the glowing wire inside a light bulb?	filament	filler	filthy	filtering		
What do you call a newborn horse?	foal	<i>No primes used</i>				
What is the name of the central area of the retina where vision is most acute?	fovea	<i>No primes used</i>				
What do you call the act of killing one's own brother?	fratricide	<i>No primes used</i>				
What do you call a small, usually open-sided roofed structure in a garden or park?	gazebo	garage	galore			
What word means to divide an area into electoral districts in order to give special advantage to one political party?	gerrymander	gerund	geriatric	gerontology		
What is the name of the unrhymed Japanese poem having 3 lines containing 5, 7, and 5 syllables?	haiku	hyena	hydraulic	hibernate	hypothesis	highway
What is the name of the disease in which blood does not clot normally, resulting in excessive bleeding?	hemophilia	helium	helix			
What word means to bleed heavily or uncontrollably?	hemorrhage	<i>No primes used</i>				
What do you call someone who holds beliefs contrary to the beliefs of the church, or anyone who does not conform with an established doctrine, principle or attitude?	heretic	heritage	heroine			

Question	Target	Prime	Prime	Prime	Prime	Prime
What is an ancient Egyptian picture-writing system?	hieroglyphics	<i>See haiku</i>				
What is the colorless, highly flammable gaseous element that is the most abundant and lightest element in the universe?	hydrogen	<i>See haiku</i>				
What do you call a person who is unnecessarily anxious about his or her health and often suffers from imaginary illnesses?	hypochondriac	<i>See haiku</i>				
What word describes something that is threatening to occur immediately, said especially of misfortune or peril?	imminent	immature	imagine			
What are the front cutting teeth called?	incisors	industry	indicate	intensity	infinity	innocence
What does it mean to keep eggs warm (as by body heat, e.g., chickens) until they hatch?	incubate	<i>See incisors</i>				
What do you call a chronic difficulty in falling asleep?	insomnia	<i>See incisors</i>				
What do you call a verb that does not require a direct object to complete its meaning?	intransitive	<i>See incisors</i>				
What is a light spear commonly used in athletic contests for distance throwing?	javelin	<i>No primes used</i>				
What word means to voluntarily sacrifice (e.g., cargo) in order to lighten a ship or aircraft's load in time of distress?	jettison	jetliner	jet-propelled			

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call the tubular viewing toy that produces symmetrical designs through an arrangement of colored chips and mirrors?	kaleidoscope	catastrophe	commemorate	capacity	<i>See cadaver and corona</i>	
What is the term for a light, mocking satire directed against an individual?	lampoon	<i>No primes used</i>				
What do you call someone who functions as a connection or link between two groups or persons, so that they can work together effectively?	liaison	leakage	legalese	lesion		
What is the term for the words or text of an opera?	libretto	<i>No primes used</i>				
What do you call the band of tissues that connects bones and keeps organs in place?	ligament	<i>No primes used</i>				
What is the term to hang or kill by mob action?	lynch	<i>No primes used</i>				
What do you call having or showing ill will towards someone, or the desire to do evil to others?	malevolence	marina	majestic	machine	magenta	majority
What is the term for the food miraculously supplied from heaven?	mana	manor	manage			
What do you call a savory sauce in which meat, fish, or a vegetable is soaked before cooking to enhance the flavor?	marinade	marrow	marry	marathon	marigold	
What is the name of the mammals (including kangaroos and opossums) that carry their young in an abdominal pouch?	marsupials	margarine	marvelous	marmalade	marketing	

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call a stone building (often found in a cemetery) with places for entombment of the dead above ground?	mausoleum	<i>No primes used</i>				
What do you call a professional soldier hired by a foreign country?	mercenary	mermaid	murky	mercy		
What is the science of investigating the weather?	meteorology	measles	meager			
How would you describe someone who is extremely careful and precise about minute details?	meticulous	medallion	metabolize	memorial	menagerie	meridian
What is the ticking device that musicians use for keeping time?	metronome	medical				
What word means to cut or chop food into very small pieces?	mince	<i>No primes used</i>				
What do you call a medieval entertainer who traveled from place to place, especially to sing and recite poetry?	minstrel	minivan	minimize			
What is the name of the criminal offense that has a lesser punishment than a felony?	misdemeanor	misfortune	miscarry			
What do you call someone who hates women?	misogynist	millenium	miraculous	militia	mirage	
What do you call any thick, brown syrup produced during the refining of sugar?	molasses	medallion	malignant	monopoly	morality	
What word means to shed hair, feathers, or an outer layer periodically, as with the changing seasons?	molt	<i>No primes used</i>				

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the term for a revolt against authority, or a rebellion of soldiers against their officers?	mutiny	muted	mutilate	mutation	musical	
What is the psychiatric term for excessive admiration of oneself?	narcissism	narcotic				
What is the term that describes an issue that is open to discussion?	negotiable	neglect	negate	necessity		
What is favoritism in hiring based on family relationships?	nepotism	<i>No primes used</i>				
What is the term for a person who collects coins?	numismatist	nudity	nuclear			
What is the term for having complete or infinite knowledge, awareness or understanding, or for being all-knowing?	omniscient	ominous	ombudsman	omelette		
What do you call an animal that eats every type of food, including meat and vegetables?	omnivore	<i>See omniscient</i>				
What do you call a word which describes a sound, where the sound made pronouncing the word is the same as the sound it describes, for example, 'bang', 'thud', and 'screech'?	onomatopoeia	onlooker	ongoing	oncology	onset	
What is the name of the art of Japanese paper folding?	origami	orchard	ordain	ordinary	organizer	orchestra
What is the term for the scientific study of birds?	ornithology	<i>See origami</i>				
What is the name of a dentist who specializes in fitting braces on teeth?	orthodontist	<i>See origami</i>				
What is the word that describes back and forth vibration in a steady uninterrupted fashion?	oscillation	osmosis	ostracism	ostentatious		

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call a word or sentence that reads the same backward or forward, such as 'Madam, I'm Adam'?	palindrome	palisade	pallet	palimony	palpable	
What is the term for telling a story without words using only symbolic, exaggerated bodily movements?	pantomime	<i>No primes used</i>				
What is the name of the Egyptian plant that is cut into strips and pressed into a material to write on?	papyrus	pajamas	paternal	pacific	parade	parabola
What do you call a statement that appears contradictory, but may be true?	paradox	paragraph	paralyze	parenting	parish	paranoia
What is the term for the organism that lives on or in another, obtaining nourishment from it?	parasite	<i>See paradox</i>				
What is a literary work that imitates the characteristic style of an author or a work for comic effect or ridicule?	parody	<i>See paradox</i>				
What is the term for the principle that the simplest explanation is best?	parsimony	parfait	partial			
What do you call the end product of exposing milk, cheese, or fermented liquids to a high temperature, killing bacteria and arresting fermentation?	pasteurize	pastoral	passage	passport	passive	
What word means to deposit something valuable as a security for money borrowed?	pawn	<i>No primes used</i>				
What is a long suspended body, lever, etc, whose lower end moves to and fro in an arc under the influence of gravity (e.g., the swinging metal piece on a grandfather clock)?	pendulum	penalty	penetrate	pension	pentagon	

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call false testimony while under oath?	perjury	percentage	perceptive	perform	permanent	perhaps
What word describes something that is at 90 degree angles to a given plane or line?	perpendicular	<i>See perjury</i>				
What is the term for converting into stone?	petrify	<i>No primes used</i>				
What do you call a person who collects and studies stamps?	philatelist	philanthropy	philosopher	phenomenon	facilitate	
What do you call the sugar pill given as medicine to a patient either to humor him/her, or used as a control in testing the efficacy of another, medicated substance?	placebo	placenta	platoon	plunder		
What word means to steal the writings or ideas of another and pass them off as one's own?	plagiarize	plaintiff	player	playwright	playful	
What is the name of the building where one can view projected images of celestial bodies on the inner surface of a dome?	planetarium	planning	plantation			
What is the name for a mixture of dried spices and flowers used for perfuming a room?	potpourri	poet	polar	ponytail		
What do you call a group or family of lions?	pride	<i>No primes used</i>				
What is the word that means to put off doing something, especially habitually, until a future time?	procrastinate	profess	profound	procedural	proficiently	proportional
What word means to seek to convert others, especially to one's religion?	proselytize	prosecute	prosthetic			

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the term for being born again, after one has already died?	reincarnate	recycle	reaction	reimbursement	reunion	
What is it called when you repeat something for emphasis?	reiterate	<i>See reincarnate</i>				
What do you call a question that is asked for effect with no answer expected?	rhetorical	resilient	recession	ricotta	risotto	ridiculous
What is a string of beads used in counting prayers?	rosary	robot	robust			
What is the term for the class of ancient Japanese warriors that wore two swords?	samurai	<i>No primes used</i>				
What is the science of investigating earthquakes?	seismology	<i>No primes used</i>				
What is the term for a performance usually given outdoors at night for a woman being courted?	serenade	serendipity	ceremony	seraphim		
What word means toothed or notched like a saw?	serrated	<i>See serenade</i>				
What is a drawing consisting of the outline of something (e.g., a face profile), usually filled with a black color?	silhouette	silicon	silly	silver		
What do you call a tall cylindrical structure, usually beside a barn, in which grain is stored?	silo	psychiatrist	psychedelic			
What is the figure of speech in which one thing is likened to another, by the use of 'like' or 'as' (e.g., a heart as big as a whale)?	simile	symposium	symmetrical	simple	symbolic	simulate
What do you call a sailboat with one mast and two sails?	sloop	<i>No primes used</i>				

Question	Target	Prime	Prime	Prime	Prime	Prime
What do you call the lines in a drama in which a character reveals his or her thoughts, only to himself (e.g., Hamlet's 'To be or not to be' speech)?	soliloquy	solicitor	solidify	societal	sophisticated	
What is an instrument that is used for turning pancakes, eggs, etc.?	spatula	<i>No primes used</i>				
What do you call a person who explores caves?	spelunker	<i>No primes used</i>				
What do you call the physical or moral power of endurance?	stamina	stampede	stammer			
What do you call a formal agreement to receive and pay for a periodical, books, theater tickets, etc. for a specified period of time?	subscription	submarine	subdivide			
What is the name of a building or place of meeting for worship and religious instruction in the Jewish faith?	synagogue	synthesis	synthetic			
What is the term for a loose outer garment worn by citizens of ancient Rome?	toga	toenail	tonal			
What do you call a missile, launched from a submarine?	torpedo	tortoise	torrid	torso	torture	tortilla
What is to make calm or serene or to reduce agitation, especially by use of a drug?	tranquelize	transcript	transcend	transfer	transmitter	transference
What do you call something that permits light to pass through it, but diffuses it enough so the object on the other side is not completely visible?	translucent	<i>See tranquilize</i>				
What is the proper name for a 'tidal wave'?	tsunami	suicide	suitable	supersede	supreme	superscript

Question	Target	Prime	Prime	Prime	Prime	Prime
What is the term for an idealized state, place, or situation of perfection?	utopia	utensil	utilize	utility		
What do you call the meat from a deer used for food?	venison	venue	vengeful	venomous	ventilate	

^aThese targets have a single phoneme as their first syllable, and their primes shared only that phoneme with the target.

Author Notes

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Table 1

Age Demographics of Participants from Experiments Included in the Present Study

Experiment	Young Adults				Older Adults			
	N	Mean	SD	Range	N	Mean	SD	Range
White & Abrams (2002)	60	20.3 yrs	1.6	18-26	80	72.0 yrs	6.3	60-83
Robinson, Abrams, & Bahrick (2004)	60	18.8 yrs	0.9	18-21	52	74.0 yrs	7.0	61-91
Abrams, White, & Eitel (2003) ^a								
Experiment 1	60	18.9 yrs	1.5	17-25				
Experiment 3	87	18.6 yrs	0.9	18-23				
Abrams & Rodriguez (2004)	60	18.8 yrs	1.0	17-21				

^aExperiment 2 used the same young adult participants in White and Abrams (2002), so their age demographics are not repeated here.

Table 2

Overall Percent of Responses to General Knowledge Questions by Age Group

Response	Young Adults		Older Adults	
	Mean	SD	Mean	SD
Correct TOT	13.6	8.6	19.4	11.3
Correct Know	30.2	24.7	41.0	24.7
Don't Know	38.7	21.6	19.3	15.9
Incorrect TOT	3.4	3.8	2.0	3.1
Incorrect Know	14.1	12.8	18.2	17.6

Table 3

Percent of “TOT”, “Know”, and “Don’t Know” Responses to General Knowledge Questions for Each Target Word

Target	# of Participants	Age Group	Correct TOT	Correct Know	Don’t Know	Incorrect TOT	Incorrect Know
abacus	294	young	27.9%	24.5%	37.8%	6.5%	3.4%
abacus	118	older	26.3%	66.1%	3.4%	2.5%	1.7%
abdicate	294	young	12.6%	16.0%	53.1%	8.8%	9.5%
abdicate	116	older	14.7%	75.0%	9.5%	0.0%	0.9%
acapella	103	young	14.6%	57.3%	9.7%	1.9%	16.5%
acapella	75	older	10.7%	64.0%	6.7%	0.0%	18.7%
actuary	293	young	7.2%	2.0%	67.9%	6.5%	16.4%
actuary	117	older	35.9%	33.3%	19.7%	2.6%	8.5%
affirmation	158	young	3.8%	0.6%	82.3%	2.5%	10.8%
affirmation	117	older	17.9%	13.7%	45.3%	2.6%	20.5%
agnostic	294	young	9.5%	21.8%	32.3%	8.8%	27.6%
agnostic	117	older	13.7%	56.4%	5.1%	0.0%	24.8%
albatross	294	young	8.5%	11.2%	53.7%	3.7%	22.8%
albatross	117	older	16.2%	58.1%	18.8%	1.7%	5.1%
alchemy	243	young	10.7%	34.2%	52.7%	0.4%	2.1%
alchemy	41	older	24.4%	56.1%	19.5%	0.0%	0.0%
amber	59	young	5.1%	33.9%	49.2%	1.7%	10.2%
amber	0	older					
ambergris	100	young	12.0%	2.0%	47.0%	4.0%	35.0%
ambergris	42	older	31.0%	11.9%	45.2%	0.0%	11.9%
ambrosia	48	young	12.5%	16.7%	64.6%	0.0%	6.3%
ambrosia	42	older	21.4%	11.9%	50.0%	0.0%	16.7%
amnesty	59	young	6.8%	0.0%	79.7%	6.8%	6.8%
amnesty	0	older					

amorous	135	young	5.2%	3.0%	60.7%	5.2%	25.9%
amorous	75	older	0.0%	22.7%	24.0%	4.0%	49.3%
anachronistic	59	young	6.8%	6.8%	74.6%	6.8%	5.1%
anachronistic	0	older					
anagram	294	young	13.9%	11.9%	64.3%	1.7%	8.2%
anagram	117	older	23.9%	22.2%	42.7%	0.9%	10.3%
anarchist	235	young	17.4%	45.5%	25.5%	5.1%	6.4%
anarchist	117	older	23.9%	37.6%	22.2%	0.0%	16.2%
anecdote	251	young	9.6%	12.7%	54.2%	6.4%	17.1%
anecdote	117	older	20.5%	6.0%	35.9%	3.4%	34.2%
aorta	103	young	13.6%	30.1%	24.3%	5.8%	26.2%
aorta	75	older	5.3%	60.0%	5.3%	5.3%	24.0%
astrology	59	young	6.8%	40.7%	39.0%	1.7%	11.9%
astrology	0	older					
atone	84	young	8.3%	1.2%	40.5%	0.0%	50.0%
atone	42	older	31.0%	42.9%	11.9%	0.0%	14.3%
bandanna	162	young	3.7%	22.8%	11.7%	2.5%	59.3%
bandanna	75	older	4.0%	33.3%	0.0%	0.0%	62.7%
barnacle	246	young	8.1%	53.3%	20.3%	1.6%	16.7%
barnacle	75	older	12.0%	80.0%	2.7%	0.0%	5.3%
barter	48	young	10.4%	83.3%	6.3%	0.0%	0.0%
barter	42	older	7.1%	85.7%	2.4%	0.0%	4.8%
beaver	59	young	0.0%	88.1%	8.5%	0.0%	3.4%
beaver	0	older					
biography	59	young	1.7%	86.4%	1.7%	0.0%	10.2%
biography	0	older					
boomerang	151	young	15.2%	76.2%	5.3%	0.7%	2.6%
boomerang	117	older	27.4%	66.7%	1.7%	2.6%	1.7%
cadaver	59	young	22.0%	40.7%	22.0%	3.4%	11.9%
cadaver	0	older					
caduceus	235	young	7.7%	1.3%	75.7%	10.2%	5.1%
caduceus	117	older	18.8%	37.6%	33.3%	1.7%	8.5%

calibration	235	young	12.8%	14.9%	48.9%	4.3%	19.1%
calibration	117	older	14.5%	30.8%	30.8%	2.6%	21.4%
calisthenics	242	young	9.5%	6.2%	29.3%	7.0%	47.9%
calisthenics	117	older	17.1%	7.7%	19.7%	7.7%	47.9%
calligraphy	293	young	11.6%	57.3%	15.7%	0.7%	14.7%
calligraphy	117	older	20.5%	52.1%	11.1%	2.6%	13.7%
canonize	59	young	6.8%	10.2%	67.8%	3.4%	11.9%
canonize	0	older					
capillary	235	young	18.3%	34.0%	40.4%	1.7%	5.5%
capillary	117	older	13.7%	48.7%	23.1%	1.7%	12.8%
carcinogen	294	young	15.6%	37.1%	26.9%	3.4%	17.0%
carcinogen	116	older	14.7%	40.5%	17.2%	0.9%	26.7%
cartographer	183	young	18.6%	26.8%	39.9%	4.4%	10.4%
cartographer	116	older	16.4%	52.6%	17.2%	0.9%	12.9%
castanets	235	young	10.6%	10.2%	56.6%	5.1%	17.4%
castanets	116	older	9.5%	61.2%	14.7%	0.9%	13.8%
catharsis	111	young	3.6%	6.3%	67.6%	8.1%	14.4%
catharsis	0	older					
chameleon	243	young	12.3%	67.9%	5.8%	2.5%	11.5%
chameleon	41	older	14.6%	82.9%	2.4%	0.0%	0.0%
cherub	59	young	5.1%	49.2%	39.0%	0.0%	6.8%
cherub	0	older					
contingency	194	young	7.2%	1.0%	67.5%	6.7%	17.5%
contingency	75	older	5.3%	0.0%	18.7%	17.3%	58.7%
contraband	246	young	24.0%	15.0%	43.5%	7.7%	9.8%
contraband	75	older	17.3%	32.0%	20.0%	4.0%	26.7%
corona	294	young	7.1%	8.5%	71.1%	6.1%	7.1%
corona	116	older	11.2%	14.7%	51.7%	2.6%	19.8%
coroner	59	young	6.8%	6.8%	25.4%	10.2%	50.8%
coroner	0	older					
cosmonaut	187	young	4.3%	28.3%	45.5%	0.0%	21.9%
cosmonaut	75	older	9.3%	52.0%	9.3%	1.3%	28.0%

covenant	235	young	9.8%	15.7%	46.0%	5.5%	23.0%
covenant	116	older	21.6%	15.5%	40.5%	0.0%	22.4%
decanter	294	young	8.8%	3.4%	49.3%	8.2%	30.3%
decanter	116	older	19.8%	38.8%	4.3%	3.4%	33.6%
desecrate	48	young	22.9%	16.7%	58.3%	0.0%	2.1%
desecrate	41	older	34.1%	31.7%	29.3%	0.0%	4.9%
determinist	241	young	12.4%	5.8%	62.2%	5.8%	13.7%
determinist	116	older	15.5%	6.9%	37.9%	5.2%	34.5%
detonate	235	young	11.1%	27.7%	30.2%	3.4%	27.7%
detonate	116	older	14.7%	44.0%	6.9%	3.4%	31.0%
dowry	48	young	25.0%	37.5%	35.4%	0.0%	2.1%
dowry	41	older	24.4%	75.6%	0.0%	0.0%	0.0%
egocentric	51	young	11.8%	3.9%	15.7%	17.6%	51.0%
egocentric	75	older	13.3%	6.7%	12.0%	2.7%	65.3%
ellipsis	210	young	9.5%	22.9%	54.8%	5.2%	7.6%
ellipsis	116	older	14.7%	2.6%	64.7%	4.3%	13.8%
embryo	294	young	18.4%	37.1%	21.8%	2.4%	20.4%
embryo	116	older	19.0%	37.9%	33.6%	0.0%	9.5%
emerald	59	young	1.7%	66.1%	11.9%	0.0%	20.3%
emerald	0	older					
encrypt	59	young	6.8%	6.8%	67.8%	0.0%	18.6%
encrypt	0	older					
endorse	107	young	18.7%	47.7%	29.9%	0.0%	3.7%
endorse	41	older	12.2%	87.8%	0.0%	0.0%	0.0%
ephemeral	51	young	5.9%	5.9%	23.5%	21.6%	43.1%
ephemeral	75	older	2.7%	0.0%	13.3%	17.3%	66.7%
epidermis	102	young	7.8%	73.5%	8.8%	2.9%	6.9%
epidermis	75	older	5.3%	68.0%	12.0%	0.0%	14.7%
epilogue	131	young	32.8%	27.5%	23.7%	1.5%	14.5%
epilogue	41	older	26.8%	24.4%	12.2%	0.0%	36.6%
equestrian	162	young	3.7%	21.0%	41.4%	4.9%	29.0%
equestrian	75	older	8.0%	38.7%	5.3%	0.0%	48.0%

Resolving Tip-of-the-Tongue 50

esoteric	135	young	13.3%	1.5%	60.0%	7.4%	17.8%
esoteric	75	older	5.3%	6.7%	29.3%	6.7%	52.0%
estrogen	59	young	13.6%	61.0%	20.3%	0.0%	5.1%
estrogen	0	older					
euphemism	211	young	9.5%	8.5%	70.6%	2.4%	9.0%
euphemism	117	older	22.2%	9.4%	51.3%	5.1%	12.0%
evangelist	109	young	5.5%	11.9%	35.8%	3.7%	43.1%
evangelist	75	older	2.7%	18.7%	1.3%	0.0%	77.3%
filament	296	young	7.8%	29.4%	56.4%	1.7%	4.7%
filament	116	older	11.2%	62.1%	19.8%	0.9%	6.0%
foal	48	young	31.3%	18.8%	18.8%	0.0%	31.3%
foal	41	older	4.9%	48.8%	17.1%	0.0%	29.3%
fovea	48	young	45.8%	27.1%	20.8%	0.0%	6.3%
fovea	41	older	26.8%	2.4%	31.7%	0.0%	39.0%
fratricide	48	young	27.1%	6.3%	62.5%	0.0%	4.2%
fratricide	41	older	24.4%	56.1%	19.5%	0.0%	0.0%
gazebo	58	young	10.3%	41.4%	31.0%	1.7%	15.5%
gazebo	0	older					
gerrymander	151	young	18.5%	9.9%	62.3%	4.0%	5.3%
gerrymander	118	older	20.3%	50.0%	22.9%	0.8%	5.9%
haiku	191	young	12.0%	66.0%	19.9%	1.0%	1.0%
haiku	43	older	23.3%	23.3%	53.5%	0.0%	0.0%
hemophilia	191	young	35.6%	27.7%	24.6%	1.6%	10.5%
hemophilia	43	older	46.5%	37.2%	11.6%	0.0%	4.7%
hemorrhage	48	young	35.4%	10.4%	50.0%	0.0%	4.2%
hemorrhage	43	older	18.6%	60.5%	14.0%	0.0%	7.0%
heretic	135	young	15.6%	7.4%	40.7%	11.1%	25.2%
heretic	75	older	10.7%	18.7%	12.0%	10.7%	48.0%
hieroglyphics	246	young	11.8%	76.8%	9.3%	0.8%	1.2%
hieroglyphics	75	older	16.0%	70.7%	6.7%	1.3%	5.3%
hydrogen	110	young	2.7%	40.0%	23.6%	8.2%	25.5%
hydrogen	75	older	4.0%	42.7%	8.0%	1.3%	44.0%

hypochondriac	191	young	29.8%	40.3%	24.6%	2.6%	2.6%
hypochondriac	43	older	27.9%	69.8%	2.3%	0.0%	0.0%
imminent	59	young	5.1%	11.9%	67.8%	3.4%	11.9%
imminent	0	older					
incisors	246	young	9.8%	39.0%	32.9%	6.1%	12.2%
incisors	75	older	4.0%	73.3%	6.7%	1.3%	14.7%
incubate	234	young	17.1%	54.7%	26.1%	0.9%	1.3%
incubate	118	older	16.1%	67.8%	6.8%	0.8%	8.5%
insomnia	294	young	23.8%	63.6%	5.8%	1.4%	5.4%
insomnia	118	older	21.2%	63.6%	8.5%	0.0%	6.8%
intransitive	194	young	5.7%	2.1%	69.1%	5.2%	18.0%
intransitive	75	older	6.7%	28.0%	26.7%	6.7%	32.0%
javelin	103	young	19.4%	56.3%	10.7%	3.9%	9.7%
javelin	75	older	9.3%	72.0%	8.0%	0.0%	10.7%
jettison	48	young	20.8%	4.2%	70.8%	0.0%	4.2%
jettison	43	older	51.2%	18.6%	25.6%	0.0%	4.7%
kaleidoscope	191	young	20.9%	59.7%	18.3%	0.0%	1.0%
kaleidoscope	43	older	48.8%	44.2%	7.0%	0.0%	0.0%
lampoon	48	young	22.9%	0.0%	70.8%	0.0%	6.3%
lampoon	43	older	41.9%	0.0%	48.8%	0.0%	9.3%
liaison	103	young	4.9%	14.6%	13.6%	4.9%	62.1%
liaison	75	older	10.7%	29.3%	2.7%	5.3%	52.0%
libretto	48	young	8.3%	2.1%	85.4%	0.0%	4.2%
libretto	43	older	18.6%	30.2%	44.2%	0.0%	7.0%
ligament	187	young	8.6%	33.7%	18.2%	4.8%	34.8%
ligament	75	older	8.0%	29.3%	4.0%	4.0%	54.7%
lynch	48	young	10.4%	41.7%	47.9%	0.0%	0.0%
lynch	43	older	37.2%	51.2%	4.7%	0.0%	7.0%
malevolence	246	young	9.3%	4.1%	45.1%	6.5%	35.0%
malevolence	75	older	14.7%	2.7%	41.3%	6.7%	34.7%
manna	107	young	6.5%	19.6%	66.4%	0.9%	6.5%
manna	43	older	4.7%	88.4%	7.0%	0.0%	0.0%

marinade	195	young	15.9%	60.0%	15.9%	1.5%	6.7%
marinade	0	older					
marsupials	294	young	20.7%	52.7%	25.5%	0.3%	0.7%
marsupials	118	older	32.2%	43.2%	21.2%	1.7%	1.7%
mausoleum	103	young	10.7%	18.4%	29.1%	14.6%	27.2%
mausoleum	75	older	8.0%	64.0%	0.0%	1.3%	26.7%
mercenary	294	young	12.2%	24.1%	57.8%	1.7%	4.1%
mercenary	118	older	25.4%	56.8%	8.5%	2.5%	6.8%
meteorology	59	young	3.4%	74.6%	20.3%	1.7%	0.0%
meteorology	0	older					
meticulous	135	young	12.6%	10.4%	21.5%	10.4%	45.2%
meticulous	75	older	14.7%	9.3%	9.3%	10.7%	56.0%
metronome	235	young	20.4%	38.3%	31.9%	4.3%	5.1%
metronome	118	older	19.5%	66.9%	6.8%	3.4%	3.4%
mince	48	young	25.0%	10.4%	27.1%	0.0%	37.5%
mince	43	older	18.6%	37.2%	7.0%	0.0%	37.2%
minstrel	59	young	6.8%	5.1%	52.5%	6.8%	28.8%
minstrel	0	older					
misdemeanor	107	young	10.3%	75.7%	13.1%	0.0%	0.9%
misdemeanor	43	older	30.2%	65.1%	4.7%	0.0%	0.0%
misogynist	242	young	11.2%	9.5%	47.5%	8.3%	23.6%
misogynist	118	older	11.9%	28.0%	36.4%	6.8%	16.9%
molasses	242	young	6.6%	30.6%	44.6%	2.1%	16.1%
molasses	118	older	7.6%	50.8%	26.3%	0.0%	15.3%
molt	48	young	33.3%	37.5%	27.1%	0.0%	2.1%
molt	41	older	36.6%	56.1%	7.3%	0.0%	0.0%
mutiny	235	young	17.4%	25.1%	23.0%	11.5%	23.0%
mutiny	116	older	15.5%	44.0%	8.6%	5.2%	26.7%
narcissism	184	young	9.8%	17.9%	47.3%	7.1%	17.9%
narcissism	41	older	26.8%	34.1%	12.2%	0.0%	26.8%
negotiable	51	young	17.6%	0.0%	49.0%	3.9%	29.4%
negotiable	75	older	12.0%	0.0%	41.3%	8.0%	38.7%

nepotism	151	young	22.5%	12.6%	51.7%	7.3%	6.0%
nepotism	116	older	37.1%	58.6%	3.4%	0.0%	0.9%
numismatist	59	young	0.0%	0.0%	86.4%	0.0%	13.6%
numismatist	0	older					
omniscient	246	young	13.8%	19.5%	31.3%	4.5%	30.9%
omniscient	75	older	10.7%	13.3%	24.0%	4.0%	48.0%
omnivore	184	young	15.2%	48.4%	21.2%	2.2%	13.0%
omnivore	41	older	31.7%	36.6%	19.5%	0.0%	12.2%
onomatopoeia	191	young	22.0%	46.6%	22.5%	4.2%	4.7%
onomatopoeia	41	older	24.4%	12.2%	53.7%	0.0%	9.8%
origami	209	young	19.6%	67.9%	11.5%	0.5%	0.5%
origami	116	older	19.0%	52.6%	21.6%	4.3%	2.6%
ornithology	58	young	17.2%	5.2%	69.0%	0.0%	8.6%
ornithology	0	older					
orthodontist	107	young	5.6%	91.6%	2.8%	0.0%	0.0%
orthodontist	40	older	10.0%	80.0%	7.5%	0.0%	2.5%
oscillation	51	young	5.9%	11.8%	62.7%	5.9%	13.7%
oscillation	75	older	9.3%	4.0%	45.3%	8.0%	33.3%
palindrome	235	young	28.9%	11.9%	48.9%	7.2%	3.0%
palindrome	116	older	41.4%	8.6%	40.5%	3.4%	6.0%
pantomime	48	young	31.3%	8.3%	50.0%	0.0%	10.4%
pantomime	41	older	29.3%	56.1%	9.8%	0.0%	4.9%
papyrus	245	young	12.7%	37.6%	44.5%	2.9%	2.4%
papyrus	75	older	6.7%	77.3%	5.3%	1.3%	9.3%
paradox	242	young	18.6%	8.7%	56.6%	3.7%	12.4%
paradox	41	older	34.1%	4.9%	56.1%	0.0%	4.9%
parasite	293	young	16.0%	56.7%	17.1%	3.4%	6.8%
parasite	117	older	20.5%	64.1%	8.5%	0.0%	6.8%
parody	48	young	27.1%	16.7%	35.4%	0.0%	20.8%
parody	40	older	37.5%	7.5%	32.5%	0.0%	22.5%
parsimony	106	young	14.2%	0.0%	81.1%	0.9%	3.8%
parsimony	40	older	32.5%	0.0%	65.0%	0.0%	2.5%

pasteurize	235	young	17.0%	29.8%	38.7%	4.7%	9.8%
pasteurize	115	older	11.3%	68.7%	9.6%	0.9%	9.6%
pawn	48	young	47.9%	0.0%	31.3%	0.0%	20.8%
pawn	40	older	47.5%	5.0%	15.0%	0.0%	32.5%
pendulum	294	young	7.5%	46.6%	39.8%	0.3%	5.8%
pendulum	116	older	10.3%	59.5%	25.9%	0.9%	3.4%
perjury	294	young	23.1%	41.8%	24.5%	1.7%	8.8%
perjury	117	older	20.5%	68.4%	4.3%	0.0%	6.8%
perpendicular	59	young	5.1%	40.7%	23.7%	3.4%	27.1%
perpendicular	0	older					
petrify	48	young	16.7%	8.3%	72.9%	0.0%	2.1%
petrify	41	older	34.1%	14.6%	39.0%	0.0%	12.2%
philatelist	183	young	9.3%	0.5%	78.1%	1.6%	10.4%
philatelist	115	older	30.4%	38.3%	15.7%	3.5%	12.2%
placebo	235	young	15.7%	63.0%	17.0%	1.7%	2.6%
placebo	41	older	29.3%	65.9%	4.9%	0.0%	0.0%
plagiarize	235	young	16.6%	80.4%	1.7%	0.0%	1.3%
plagiarize	40	older	20.0%	80.0%	0.0%	0.0%	0.0%
planetarium	132	young	33.3%	15.9%	34.8%	4.5%	11.4%
planetarium	40	older	52.5%	25.0%	15.0%	0.0%	7.5%
potpourri	294	young	7.8%	83.7%	6.1%	0.0%	2.4%
potpourri	115	older	40.0%	40.0%	9.6%	2.6%	7.8%
pride	48	young	27.1%	33.3%	25.0%	0.0%	14.6%
pride	40	older	17.5%	75.0%	0.0%	0.0%	7.5%
procrastinate	294	young	8.2%	80.6%	8.8%	0.0%	2.4%
procrastinate	115	older	14.8%	66.1%	9.6%	5.2%	4.3%
proselytize	59	young	10.2%	3.4%	64.4%	16.9%	5.1%
proselytize	0	older					
reincarnate	246	young	11.8%	66.3%	8.1%	1.2%	12.6%
reincarnate	75	older	6.7%	37.3%	6.7%	0.0%	49.3%
reiterate	294	young	21.1%	14.3%	46.9%	3.4%	14.3%
reiterate	114	older	23.7%	13.2%	39.5%	2.6%	21.1%

rhetorical	194	young	13.9%	51.0%	23.7%	1.0%	10.3%
rhetorical	75	older	9.3%	32.0%	33.3%	4.0%	21.3%
rosary	59	young	6.8%	69.5%	20.3%	3.4%	0.0%
rosary	0	older					
samurai	48	young	6.3%	64.6%	27.1%	0.0%	2.1%
samurai	39	older	7.7%	84.6%	7.7%	0.0%	0.0%
seismology	48	young	27.1%	16.7%	50.0%	0.0%	6.3%
seismology	41	older	31.7%	39.0%	22.0%	0.0%	7.3%
serenade	48	young	4.2%	25.0%	68.8%	0.0%	2.1%
serenade	40	older	15.0%	65.0%	20.0%	0.0%	0.0%
serrated	187	young	10.2%	26.2%	49.2%	3.2%	11.2%
serrated	75	older	10.7%	37.3%	25.3%	2.7%	24.0%
silhouettes	235	young	16.6%	23.4%	42.1%	1.7%	16.2%
silhouettes	115	older	14.8%	36.5%	28.7%	4.3%	15.7%
silo	59	young	8.5%	35.6%	45.8%	1.7%	8.5%
silo	0	older					
simile	293	young	9.9%	70.3%	7.2%	4.1%	8.5%
simile	115	older	24.3%	21.7%	21.7%	6.1%	26.1%
sloop	47	young	6.4%	0.0%	89.4%	0.0%	4.3%
sloop	40	older	17.5%	10.0%	65.0%	0.0%	7.5%
soliloquy	191	young	23.6%	19.4%	17.8%	6.3%	33.0%
soliloquy	40	older	25.0%	37.5%	30.0%	0.0%	7.5%
spatula	52	young	5.8%	88.5%	3.8%	0.0%	1.9%
spatula	0	older					
spelunker	100	young	16.0%	20.0%	51.0%	1.0%	12.0%
spelunker	42	older	35.7%	42.9%	19.0%	0.0%	2.4%
stamina	51	young	7.8%	19.6%	58.8%	2.0%	11.8%
stamina	75	older	9.3%	33.3%	22.7%	5.3%	29.3%
subscription	59	young	5.1%	33.9%	42.4%	1.7%	16.9%
subscription	0	older					
synagogue	59	young	5.1%	45.8%	13.6%	3.4%	32.2%
synagogue	0	older					

toga	106	young	8.5%	64.2%	21.7%	0.0%	5.7%
toga	38	older	5.3%	81.6%	10.5%	0.0%	2.6%
torpedo	210	young	6.2%	40.0%	46.7%	1.9%	5.2%
torpedo	116	older	17.2%	41.4%	20.7%	1.7%	19.0%
tranquilize	294	young	19.4%	7.1%	32.3%	4.8%	36.4%
tranquilize	115	older	28.7%	19.1%	11.3%	4.3%	36.5%
translucent	187	young	11.8%	13.4%	32.6%	17.6%	24.6%
translucent	75	older	12.0%	28.0%	8.0%	6.7%	45.3%
tsunami	294	young	10.2%	43.9%	36.4%	1.4%	8.2%
tsunami	115	older	14.8%	47.0%	19.1%	4.3%	14.8%
utopia	210	young	15.7%	39.5%	28.1%	1.4%	15.2%
utopia	114	older	26.3%	32.5%	12.3%	1.8%	27.2%
venison	246	young	8.1%	50.4%	32.1%	2.4%	6.9%
venison	75	older	9.3%	90.7%	0.0%	0.0%	0.0%

Table 4

Alternate Words Available During TOTs or Incorrectly Retrieved as Targets Following “Know” Responses

Target	Age Group	Most Frequent Alternate (N)	Alternate (N)	Alternate (N)	Alternate (N)
abacus	young	sliderule/r (12)	calculator (11)	meniscus (3)	
abacus	older	calculator (2)			
abdicate	young	resign (31)	dethrone (20)	step down (13)	
abdicate	older	abduct (2)	renounce (2)		
acappella*	young	solo (34)	acoustic (4)	vocal (3)	
acappella	older	solo (21)			
actuary	young	accountant (25)	insurance agent (23)	adjuster (13)	
actuary	older	adjuster (8)	statistician (5)	analyst (3)	
affirmation	young	taking the 5 th (8)	promise (7)	testimony (3)	
affirmation	older	conscientious objector (19)	objection (9)	taking the 5 th (7)	
agnostic*	young	atheist (166)	scientist (5)	skeptic/al (5)	
agnostic	older	atheist (54)			
albatross	young	seagull (81)	pelican (71)	dove (11)	
albatross	older	swan (3)	seagull (2)		
alchemy	young	chemistry (7)	melting (3)	blacksmith (2)	ore (2)
alchemy ^a	older	N/A			
ambergris	young	blubber (53)	oil (9)	fat (7)	
ambergris	older	sperm oil (2)			
amber	young	gold (8)			
amber ^b	older	-----			
ambrosia ^a	young	N/A			
ambrosia	older	nectar (4)			

amnesty	young	pardon (11)	Clinton (2)		
amnesty ^b	older	N/A			
amorous*	young	affection (12)	romantic (10)	lust (9)	
amorous	older	affectionate (20)	lovable (12)	lover (8)	
anachronistic ^a	young	N/A			
anachronistic ^b	older	-----			
anagram*	young	jumble (27)	scramble (22)	puzzle (9)	acronym (9)
anagram	older	jumble (5)	puzzle (5)	scramble (4)	
anarchist	young	communist (22)	radical (7)	monarchy (4)	
anarchist	older	liberalist (9)	radical (2)	revolutionary (2)	
anecdote	young	story (24)	summary (14)	biography (7)	
anecdote	older	essay (31)	story (14)	synopsis (9)	
aorta	young	heart (36)	coratid (12)	jugular (8)	
aorta	older	coratid (25)	heart (8)	coronary (5)	vein (5)
astrology	young	astronomy (7)	Gallileo (2)	horoscope (2)	
astrology ^b	older	-----			
atone	young	apology (23)	repent (8)	reconciliation (4)	
atone	older	penance (4)	repent (2)		
bandanna	young	scarf (184)	kerchief (7)	tie (6)	
bandanna	older	kerchief (44)	scarf (38)		
barnacle	young	snail(s) (28)	clams (12)	crustacean (10)	
barnacle	older	mussels (5)	snail (2)		
barter ^a	young	N/A			
barter	older	swap (2)			
beaver ^a	young	N/A			
beaver ^b	older	-----			
biography	young	autobiography (6)			
biography ^b	older	-----			
boomerang	young	Frisbee (3)	Australian (2)		
boomerang ^a	older	N/A			
cadaver	young	corpse (6)	specimen (3)	carcass (2)	
cadaver ^b	older	-----			

caduceus	young	blue cross blue shield (12)	red cross (8)	Hippocratic symbol (4)	physician(4)
caduceus	older	medusa/s (7)	doctor (6)		
calibration	young	in tune (34)	converting (14)	standardizing (13)	
calibration	older	synchronize (8)	standardizing (7)	alignment (2)	
calisthenics*	young	aerobics (64)	cardio (54)	yoga (41)	
calisthenics	older	aerobics (75)	dancing (7)	gymnastics (5)	
calligraphy	young	cursive (16)	penmanship (4)	manuscripts (3)	
calligraphy	older	penmanship (19)	spencercian (6)	palmer method (4)	
canonize	young	sanctify (3)	martyr (3)		
canonize ^b	older	-----			
capillary*	young	blood vessels (16)	ventricle (9)	vesicle (5)	
capillary	older	blood vessels (5)	areolas (4)	corpuscle (4)	
carcinogen	young	tumor (23)	cancerous (19)	malignant (19)	
carcinogen	older	malignant (6)	cigarette(s) (5)	cell (4)	
cartographer	young	mapmaker (19)	topographer (15)	cipher (3)	geologist (3)
cartographer	older	cartologist (15)	cardiologist (4)		
castanets*	young	tambourine (26)	drums (24)	finger cymbals (15)	maracas (15)
castanets	older	tambourine (10)	maracas (8)	bongo (6)	
catharsis	young	therapy (8)	hypnosis (6)	confession (4)	
catharsis ^b	older	-----			
chameleon	young	gecko (27)	iguana (20)	salamander (3)	
chameleon ^a	older	N/A			
cherub ^a	young	N/A			
cherub ^b	older	-----			
contingency	young	coincidence (21)	fate (15)	luck (14)	
contingency	older	happenstance (21)	accident (16)	random (14)	
contraband	young	black-market (44)	smuggled (35)	bootlegged (10)	
contraband	older	smuggled (29)	black-market (6)	bootlegged (3)	illicit trade (3)
corona*	young	stratosphere (16)	ozone layer (11)	halo (5)	
corona	older	stratosphere (18)	ionosphere (13)	cornea (4)	ozone layer (4)
coroner	young	detective (20)	investigator (3)	forensics (2)	
coroner ^b	older	-----			

cosmonaut*	young	astronaut (100)	captain (4)	aeronaut (4)	
cosmonaut	older	astronaut (37)			
covenant	young	contract (59)	commandment (12)	oath (10)	
covenant	older	commandment (15)	bible (4)	promises (3)	
decanter	young	bottle (99)	carafe (42)	flask (23)	
decanter	older	carafe (51)	bottle (9)	flask (3)	
desecrate ^a	young	N/A			
desecrate ^a	older	N/A			
determinist*	young	fate/fatalist (21)	predestination (9)		
determinist	older	fatalist (33)	predestination (6)	pessimist (5)	
detonate*	young	ignite (94)	trigger (15)	activate (8)	
detonate	older	ignite (48)	activate (4)	trigger (4)	
dowry ^a	young	N/A			
dowry ^a	older	N/A			
egocentric	young	selfish (27)	narcissistic (16)	egotistical (13)	
egocentric	older	egotist (39)	self-centered (20)	selfish (16)	
ellipsis*	young	ellipse (18)	etceteras (15)	asterisk(s) (7)	
ellipsis	older	ellipse/s (5)	dash (4)	pause (4)	
embryo*	young	fetus (51)	zygote (41)	baby (5)	
embryo	older	fetus (11)	baby (7)	unborn child (3)	
emerald	young	jade (7)			
emerald ^b	older	-----			
encrypt	young	encode (13)	codify (2)		
encrypt ^b	older	-----			
endorse	young	verify (2)	sign (2)	authenticate (2)	
endorse ^a	older	N/A			
ephemeral	young	short (21)	fleeting (5)	quick (4)	shortly (4)
ephemeral	older	momentary (16)	instant (14)	fleeting (13)	
epidermis	young	endoderm (4)	ectoderm (4)		
epidermis	older	derma (15)			
epilogue	young	conclusion (11)	afterward (11)	prologue (6)	
epilogue	older	addendum (8)	afterward (2)	appendix (2)	postscript (2)

equestrian*	young	jockey (58)	horseback rider (26)	cowboy (14)	
equestrian	older	jockey (35)	horseback rider (12)	horseman (11)	
esoteric*	young	incomprehensible (14)	secret (11)	inside joke (10)	
esoteric	older	incomprehensible (21)	unfathomable (12)	mystery (8)	
estrogen	young	progesterone (2)	testosterone (2)		
estrogen ^b	older	-----			
euphemism	young	ensorship (12)	politically correct (12)	replacement (4)	
euphemism	older	politically correct (6)	tact (4)	polite (3)	
evangelist*	young	minister (21)	priest (20)	reverend (16)	
evangelist	older	minister (80)	pastor (14)	priest (10)	reverend (10)
filament	young	fuse (12)	wires (9)	flint (7)	
filament	older	tungsten (6)	element (5)	light (4)	
foal*	young	colt (5)	pony (4)	fawn (3)	
foal	older	colt (12)			
fovea	young	pupil (6)	cornea (3)		
fovea	older	macular (5)	cornea (3)	lens (2)	pupil (2)
fratricide	young	murder (2)			
fratricide ^a	older	N/A			
gazebo	young	pavilion (4)	canopy (2)		
gazebo ^b	older	-----			
gerrymander	young	favoritism (4)	districts (3)	separate (3)	
gerrymander	older	redistricting (4)	districts (3)		
haiku	young	sonnet (3)			
haiku ^a	older	N/A			
hemophilia	young	anemia (15)	hemorrhage (5)	hemoglobin (3)	
hemophilia ^a	older	N/A			
hemorrhage ^a	young	N/A			
hemorrhage	older	hemophilia (2)			
heretic	young	nonconformist (28)	rebel (17)	atheist (14)	
heretic	older	agnostic (23)	atheist (14)	nonconformist (7)	
hieroglyphics	young	calligraphy (4)			
hieroglyphics	older	cuneiform (3)	pictograph (3)		

hydrogen*	young	helium (24)	oxygen (14)	nitrogen (7)	
hydrogen	older	helium (35)	oxygen (20)	gas (4)	
hypochondriac	young	paranoia (6)	obsessive-compulsive(4)	delusion (2)	hallucination (2)
hypochondriac ^a	older	N/A			
imminent	young	omen (4)	impending (4)	perilous (2)	
imminent ^b	older	-----			
incisors	young	canines (29)	bi/cuspids (26)		
incisors	older	cuspids (6)	canines (4)		
incubate	young	insulate (5)	hibernation (3)	fermentation (3)	
incubate	older	brooder (8)	nesting (4)		
insomnia	young	narcolepsy (19)	sleep apnea (11)	amnesia (4)	
insomnia	older	amnesia (7)	sleep apnea (7)		
intransitive*	young	adverb (41)	indirect object (8)	action (6)	passive (6)
intransitive	older	adverb (26)	indirect verb (7)	passive (5)	
javelin*	young	discus (5)	shot put (4)	disk (4)	
javelin	older	discus (8)	lance (4)	spear (3)	
jettison ^a	young	N/A			
jettison ^a	older	N/A			
kaleidoscope	young	telescope (3)	spectroscope (2)		
kaleidoscope ^a	older	N/A			
lampoon ^a	young	N/A			
lampoon ^a	older	N/A			
liaison*	young	mediator (117)	middleman (10)	ally (3)	ambassador (3)
liaison	older	mediator (28)	facilitator (13)	go between (10)	
libretto ^a	young	N/A			
libretto ^a	older	N/A			
ligaments	young	tendon/s (58)	muscles (33)	cartilage (27)	
ligaments	older	muscle/s (51)	cartilage (15)	tendon(s) (13)	
lynch ^a	young	N/A			
lynch ^a	older	N/A			
malevolence	young	malicious (53)	hatred (49)	evil (7)	mean (7)
malevolence	older	vindictive (6)	hatred (5)	malicious (4)	misfortune (4)

manna	young	ambrosia (4)	bread (3)		
manna ^a	older	N/A			
marinade	young	broth (6)	sauté (6)	oil (3)	seasoning (3)
marinade ^b	older	-----			
marsupial	young	kangaroo (5)	pouch (4)	mammals (3)	kingdoms (3)
marsupial ^a	older	N/A			
mausoleum	young	tomb(stone)/s (60)	crypt/s (8)		
mausoleum	older	crypt/s (16)	tomb(stone) (14)		
mercenary*	young	spy (16)	guerilla (7)	soldier (5)	
mercenary	older	spy (6)	legionnaire (6)	soldier of fortune (3)	
meteorology ^a	young	N/A			
meteorology ^b	older	-----			
meticulous*	young	perfectionist (44)	anal (38)	obsessive compulsive disorder (7)	
meticulous	older	perfectionist (37)	picky (12)	precise (9)	
metronome	young	meter (13)	clock (9)	pendulum (7)	
metronome	older	pendulum (2)			
mince*	young	dice (17)			
mince	older	dice (15)			
minstrel	young	jester (14)	Shakespeare (2)	bard (2)	joker (2)
minstrel ^b	older	-----			
misdemeanor ^a	young	N/A			
misdemeanor ^a	older	N/A			
misogynist*	young	chauvinist (47)	sexist (37)	anti-feminist (9)	
misogynist	older	chauvinist (15)	woman hater (12)	anti-feminist (6)	
molasses*	young	(maple) syrup (30)	sap (12)		
molasses	older	(cane) syrup (20)			
molt ^a	young	N/A			
molt ^a	older	N/A			
mutiny	young	coup (22)	revolution (18)	revolt (15)	
mutiny	older	insurrection (22)	coup (17)	revolution (12)	
narcissism	young	self-esteem (16)	conceited (15)	egotism (15)	
narcissism	older	egotism (8)	egocentric (2)		

negotiable*	young	debate (28)	topic (6)	controversial (4)	
negotiable	older	debate (22)	on the table (6)	moot (6)	
nepotism	young	bias (15)	discrimination (12)	favoritism (11)	
nepotism ^a	older	N/A			
numismatist	young	(coin) collector (19)			
numismatist ^b	older	-----			
omniscient*	young	omnipotent (81)	genius (38)	wise (8)	
omniscient	older	omnipotent (34)	genius (12)	God (6)	wise (6)
omnivore*	young	carnivore (56)	herbivore (13)	mammal (4)	
omnivore	older	carnivore (5)			
onomatopoeia*	young	synonym (3)	oxymoron (3)	alliteration (2)	
onomatopoeia	older	synonym (3)			
origami	young	papier-mâché (3)			
origami ^a	older	N/A			
ornithology	young	aviary (2)			
ornithology ^b	older	-----			
orthodontist ^a	young	N/A			
orthodontist ^a	older	N/A			
oscillation	young	wave/s (7)	rhythm (4)	sway (3)	vibrate (3)
oscillation	older	rhythm (7)	vibrate (6)	harmonic/s (4)	motion (4)
palindrome*	young	anagram (17)	acronym (6)	homonym (5)	idiom (5)
palindrome	older	anagram (10)			
pantomime	young	charade/s (2)			
pantomime ^a	older	N/A			
papyrus	young	eucalyptus (8)	reed (7)	aloe (5)	paper (5)
papyrus	older	papaya (2)			
paradox	young	oxymoron (34)	ironic (12)	contradictory (9)	
paradox ^a	older	N/A			
parasite	young	symbiotic (11)	leech (7)	bacteria (7)	
parasite	older	leech (7)			
parody*	young	satire (10)			
parody	older	satire (6)	mimic (2)		

parsimony	young	simplicity (4)	concise (2)		
parsimony ^a	older	N/A			
pasteurize*	young	homogenization (13)	mold (8)	boiling (8)	
pasteurize	older	homogenization (10)	sterilizing (6)		
pawn*	young	collateral (8)			
pawn	older	collateral (19)			
pendulum	young	seesaw (13)	pulley (10)	lever (5)	
pendulum	older	fulcrum (5)			
perjury*	young	lie (80)	Clinton (5)	treason (2)	
perjury	older	lie (18)			
perpendicular	young	right angle (20)			
perpendicular ^b	older	-----			
petrify ^a	young	N/A			
petrify	older	fossilize (2)			
philatelist	young	stamp collector (64)	hobby (3)	stampographer (3)	
philatelist	older	numismatist (13)	stamp collector (10)		
placebo	young	glucose (3)	diabetes (2)	pseudo (2)	
placebo	older	placenta (3)			
plagiarize ^a	young	N/A			
plagiarize ^a	older	N/A			
planetarium*	young	observatory (12)	projector (5)	IMAX theater (3)	Sistine Chapel (3)
planetarium	older	observatory (3)			
potpourri	young	incense (8)	fragrant (3)		
potpourri	older	sachet (10)	incense (6)	deodorant (3)	scents (3)
pride	young	pack (5)			
pride	older	den (3)			
procrastinate	young	tardiness (4)	delay (3)	lateness (3)	lazy (3)
procrastinate	older	stalling (4)	delay (3)		
proselytize	young	missionary (7)	convert (3)	Mormon (3)	evangelist (2)
proselytize ^b	older	-----			
reincarnate*	young	resurrection (42)	rebirth (11)	evolution (2)	life after death (2)
reincarnate	older	resurrection (53)	reborn/rebirth (19)		

reiterate*	young	emphasize (52)	repetition (31)	stress (10)	
reiterate	older	emphasize (16)	stress (9)	restate (6)	
rhetorical*	young	hypothetical (33)			
rhetorical	older	hypothetical (15)	redundant (4)	shocker (4)	
rosary	young	beads (3)			
rosary ^b	older	-----			
samurai ^a	young	N/A			
samurai ^a	older	N/A			
seismology	young	geology (2)			
seismology	older	seismography (2)			
serenade ^a	young	N/A			
serenade ^a	older	N/A			
serrated*	young	jagged (30)	sharp (7)	rigid (6)	
serrated	older	jagged (12)	saw tooth (9)	segregated (3)	
silhouettes*	young	sketch (32)	shadow (22)	profile (14)	
silhouettes	older	sketch (17)	cartoon (5)	profile (2)	etching (2)
silo	young	barrel (2)			
silo ^b	older	-----			
simile*	young	metaphor (34)	analogy (14)	synonym (2)	
simile	older	metaphor (15)	comparison (13)	analogy (11)	
sloop	young	catamaran (2)			
sloop ^a	older	N/A			
soliloquy	young	monologue (51)	aside (23)	narration (2)	dramatic irony (2)
soliloquy	older	aside (2)			
spatula ^a	young	N/A			
spatula ^b	older	-----			
spelunker	young	archeologist (11)	excavist (8)	cave diver (7)	
spelunker ^a	older	N/A			
stamina	young	strength (14)	will (2)		
stamina	older	fortitude (11)	perseverance (9)	endurance (4)	faith (4)
subscription	young	contract (9)	ticket (2)		
subscription ^b	older	-----			

synagogue	young	temple (20)	mosque (2)		
synagogue ^b	older	-----			
toga	young	robe (4)			
toga ^a	older	N/A			
torpedo	young	missiles (15)	bomb (8)	projectile (3)	
torpedo	older	rocket (13)	missiles (9)	Polaris (8)	
tranquilize*	young	sedation (129)	anesthesia (18)	relaxed (12)	
tranquilize	older	sedation (52)	pacify (8)	medicate (6)	
translucent*	young	opaque (51)	prism (22)	transparent (13)	
translucent	older	opaque (43)	prism (12)	filter (4)	lens (4)
tsunami	young	monsoon (29)	typhoon (10)	transverse wave (4)	
tsunami	older	typhoon (8)	surge (5)		
utopia*	young	nirvana (23)	paradise (10)	bliss (6)	euphoria (6)
utopia	older	nirvana (27)	heaven (14)	paradise (12)	
venison	young	(deer) meat (15)	veal (9)		
venison ^a	older	N/A			

Note. The number of people who gave each alternate are shown in parentheses.

^aThese targets had no alternates given.

^bThese targets were never presented to older adults.

*These were targets where young and older adults had the same most frequent alternate.