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The Tip-of-the-Tongue Phenomenon: Who, What, and Why

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Abstract

The process of speech production occurs relatively effortlessly, despite complex cognitive processes that underlie word retrieval. However, sometimes these processes do break down and result in a production failure called a tip-of-the-tongue (TOT) state. TOTs are temporary word-finding problems, characterized by an inability to retrieve a word at an intended time despite a strong feeling of knowing the word. TOTs are of particular relevance to older adults, who report having more TOTs and rate them as their most frustrating cognitive failure. The present chapter reviews the relevant literature on age-related changes observed in the TOT phenomenon, with a specific investigation of factors that increase the likelihood of older adults having TOTs as well as those that promote or inhibit TOT resolution. We begin by defining TOTs and their underlying causes in the context of theories of language production. We then discuss empirical findings that examine older adults' disproportionate vulnerability in experiencing TOTs, the ways in which the incidence and resolution of TOTs can be exacerbated or mitigated, the particular susceptibility of proper names to TOTs, and comparisons of healthy older adults with adults with some clinical memory disorders. The chapter concludes with a brief discussion of suggestions for future research directions that may shed light on other unique contributors to these language production failures in old age.

The Tip-of-the-Tongue Phenomenon: Who, What, and Why

In the course of conversation, almost all speakers, irrespective of variables like age or native language, have experienced a tip-of-the-tongue (TOT) state, which represents a temporary and often frustrating inability to retrieve an intended word (e.g., Burke, MacKay, Worthley, & Wade, 1991; Burke & Shafto, 2004; Gollan, Ferreira, Cera, & Flett, 2014; Gollan, Montoya, & Bonnani, 2005; Miozzo & Caramazza, 1997). Even people who use sign language, whether hearing-impaired or not, experience language production failures in the form of "tip-of-the-fingers" (Pyers, Gollan, & Emmorey, 2009; Thompson, Emmorey, & Gollan, 2005), and speakers of logographic writing systems like Chinese can temporarily forget the visual representation of a character, resulting in a "tip-of-the-pen" experience (see Brown, 2012, for a review). The ubiquity of this experience, along with a noticeable increase in TOTs that accompanies normal aging, has made this phenomenon the focus of numerous research studies.

What is a TOT, and why does it occur?

One of the earliest known references for describing a TOT, without using the term itself, is James (1893), who summarized the experience as follows:

> Suppose we try to recall a forgotten name. The state of our consciousness is peculiar. There is a gap therein; but no mere gap. It is a gap that is intensely active. A sort of wraith of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness and then letting us sink back without the longed-for term. If wrong names are proposed to us, this singularly definite gap acts immediately so as to negate them. They do not fit the mould. And the gap of one word does not feel like the gap of another, all empty of content as both might seem necessarily to be when described as gaps (p.251).

Laboratory research on TOTs did not begin until more than 70 years later, with Brown and McNeill's (1966) seminal empirical study, where they developed a methodology of inducing TOTs in a laboratory setting. They presented definitions whose answers corresponded to a low-frequency word (e.g., *ambergris*) and asked participants to try and recall the word. Participants who experienced a TOT were asked to record various characteristics of the TOT word, including the number of syllables, first letter, and words with similar sound or meaning. They found that people reported TOTs (360 instances for 56 participants, each of whom heard 49 definitions), which were often accompanied by the retrieval of partial information even when the word itself could not be retrieved. These results documented TOTs as a reliable phenomenon that could effectively be produced in the laboratory and quantified aspects of the TOT state, contributions that were invaluable for subsequent research (see also Brown, 2012, for a historical review).

Early theories about the etiology of TOTs proposed an inhibition explanation, in which TOTs result from a more accessible, alternative word (i.e., interloper) coming to mind first and subsequently blocking retrieval of the intended word (e.g., Brown, 1979; Jones, 1989; Jones & Langford, 1987; Reason & Lucas, 1984; Roediger, 1974; Woodworth, 1929). Some studies provided support for this hypothesis by showing that TOTs could be increased following presentation of a word that was phonologically related (i.e., sharing sounds) to the TOT word. For example, presentation of the word *dissociation* resulted in more TOTs when participants were trying to retrieve *diminuendo* compared to when an unrelated word was presented (e.g., Jones, 1989; Jones & Langford, 1987; see also Maylor, 1990a). However, subsequent research revealed methodological problems with some of these studies (e.g., improper counterbalancing such that questions preceded by a phonologically related word were more difficult to answer and

therefore inherently more prone to TOTs; Meyer & Bock, 1992; Perfect & Hanley, 1992), and ultimately there was little empirical support for blocking as the cause of TOTs.

Alternatively, the cause of TOTs has been specified within theories of speech production. Although theories differ, they generally agree that speakers must complete several stages of processing before articulation of a word begins and results in successful speech production. Specifically, the speaker first chooses the underlying concept to be expressed, then undergoes the process of lexical selection by choosing an abstract word (lemma) that best reflects the concept's meaning and specifies the appropriate syntactic properties, such as its grammatical class. Once selected, the lemma undergoes phonological encoding by transmitting activation to the word's phonology, e.g., syllables and phonemes, so that the word can be articulated. TOTs are thought to involve a breakdown between lexical selection and phonological encoding, where lemma selection was completed successfully, but phonological encoding of the lemma was not (e.g., Burke et al., 1991; Dell, 1986; Levelt, 1989; but see Caramazza & Miozzo, 1997). Retrieval of partial information, as demonstrated by Brown and McNeill (1966), shows that phonological encoding can be partially completed, giving a speaker access to some of the TOT word’s phonological information, such as its first letter/phoneme or number of syllables. To produce the word, however, phonological encoding of the lemma must be completed in its entirety.

This breakdown between lexical selection and phonological encoding seems to be exacerbated in old age, evidenced by older adults experiencing more TOTs than young adults, both in self-report diaries and experimental settings (e.g., Brown & Nix, 1996; Burke, Locantore, Austin, & Chae, 2004; Burke et al., 1991; Maylor, 1990b, 1997; Salthouse & Mandell, 2013). In fact, TOTs are often cited as one of the most commonly experienced memory problems, with TOTs for proper names as older adults' most troubling cognitive problem (Cohen & Burke, 1993;

Cohen & Faulkner, 1986; Lovelace & Twohig, 1990; Ossher, Flegal, & Lustig, 2013; Sunderland, Watts, Baddeley, & Harris, 1986). Understanding *why* TOTs increase with normal aging is important for several reasons. One is that it can help to discriminate between healthy and pathological aging. Knowing what is a "normal" amount of TOTs for a given age range can help us to better understand when older adults' memory failures are typical or whether they may be an indicator of pathological declines associated with advancing age, such as Alzheimer's disease (AD) or mild cognitive impairment (MCI). In fact, naming difficulties have been identified as among the most functionally debilitative consequences of dementias (Croot, 2009; Gonzalez Rothi et al., 2009; Reilly, Martin, & Grossman, 2005). Another reason is that even in healthy aging, experiencing TOTs has important social consequences. Older adults may withdraw from social interactions if they feel like their TOTs are disrupting conversations or creating a perception of incompetence (e.g., Cohen, 1994; James & Burke, 2000). Thus, an understanding of TOTs is also critical for helping older adults to maintain social and communicative competence.

Theoretical Perspectives of Older Adults' TOT Incidence

What is it about the aging process specifically that leads to experiencing more TOTs? Two theoretical perspectives have been proposed to explain the higher rate of TOT incidence in older adults: (1) The Transmission Deficit Hypothesis (TDH; e.g., MacKay & Burke, 1990), and (2) The Inhibition Deficit Hypothesis (IDH; e.g., Zacks & Hasher, 1994).

Transmission Deficit Hypothesis. Derived from a theory of language production called the Node Structure Theory (MacKay, 1987), the most highly specified explanation of TOTs in old age comes from TDH. Recall that TOTs are thought to result between the processes of lexical selection and phonological encoding, which are defined within TDH as individual

connections between lemmas and each of their phonological components or nodes. TDH proposes that there are three specific factors that cause these connections to weaken and experience deficits in the transmission of activation, which result in TOTs (Burke et al., 1991; MacKay & Burke, 1990). One factor is *low frequency of use*, so that infrequently-used words, like those used in Brown and McNeill (1966), are more likely to result in a TOT (see also Burke et al., 1991; Harley & Bown, 1998). Another factor is *nonrecent use*, where words not used or encountered recently, such as the name of one's third grade teacher, are more susceptible to TOTs (e.g., Rastle & Burke, 1996). The most relevant factor for the present discussion is the *normal aging* process: As we age, the language production system becomes less efficient such that links between all nodes become weakened to some degree.

Although declines in connection integrity are diffusely distributed, the organizational hierarchy of the nodes renders some links more vulnerable to transmission deficits than others (see Figure 1). The retrieval of a given phonological node from the phonological system is particularly susceptible to transmission failures because it is dependent on a single, isolated connection between a word’s lexical node (lemma) and its phonology. Consequently, older adults' connections between conceptual information and phonological word forms, which can also be degraded from infrequent and nonrecent use, are particularly susceptible to transmission deficits (e.g., Burke et al., 1991; Burke & Shafto, 2004, 2008; MacKay & Burke, 1990). When the system becomes compromised in this fashion, activation is not easily transmitted across these links, and access to phonology is limited or incomplete, leading to higher TOT incidence for older adults. This explanation also illustrates why older adults often report little to no phonological information during a TOT in contrast to their young adult counterparts, who frequently remember a few letters or the number of syllables for the nonretrieved word (Brown

& Nix, 1996; Burke et al., 1991; Cohen & Faulkner, 1986; Dahlgren, 1998; Maylor, 1990a). In contrast, connections within the semantic system, e.g., between propositional and lexical nodes, are more resistant to age-related transmission deficits because multiple connections (rather than a single one) are involved in activating a lexical node. This structure allows for a convergence of priming upon a lexical node, which can offset age-related transmission deficits in any one semantic-to-lemma connection. Consequently, retrieval of semantic information is less susceptible to age-related declines than retrieval of phonological information (e.g., Mortensen, Meyer, & Humphreys, 2006).

Recent neurophysiological evidence also supports the claim that TOTs result from a deficit at the phonological level (see Díaz, Lindín, Galdo-Álvarez, & Buján, 2014, for a review on neurofunctional correlates), which is further exacerbated by age-related changes in the brain. While they are having TOTs, older adults exhibit reduced activity in the left insula, an important region for phonological production, which is presumed to reflect increased difficulty in retrieving and encoding the appropriate phonology for the target word (Shafto, Stamatakis, Tam, & Tyler, 2010). Likewise, age-related atrophy in this region has been linked to higher TOT incidence (Shafto, Burke, Stamatakis, Tam, & Tyler, 2007). Similar research has investigated the role of the superior longitudinal fasciculus (SLF), an area traditionally associated with phonological processing impairments in developmental dyslexia (Dougherty et al., 2007). When white matter density in the SLF is low, as one would expect from normal neuronal deterioration taking place during the aging process, TOTs occur with greater frequency (Stamatakis, Shafto, Williams, Tam, & Tyler, 2011). Taken together, these findings further support the proposal that an increase in TOTs during old age reflects deficits at the phonological level that prevent successful speech production.

Inhibition Deficit Hypothesis. An alternative explanation that has been posited to account for age-related declines in word retrieval more generally is IDH, which emphasizes the importance of inhibitory control for effective speech production. In general, successful goal-oriented behavior is attributable at least in part to our capacity to curb unnecessary or distracting information and focus on the task at hand (e.g., Awh, Matsukura, & Serences, 2003; McClelland & Rumelhart, 1981; Ridderinkhof, Band, & Logan, 1999). The IDH proposes that this ability erodes as we age, leaving us susceptible to a barrage of information competing for our attention (Hasher & Zacks, 1988; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Yoon, May, & Hasher, 2000). Although this theory has been used extensively to explore other cognitive impairments such as visual attention or executive function (e.g., Mund, Bell, & Buchner, 2010; Ortega, Gómez-Ariza, Román, & Bajo, 2012), the universality of inhibitory deficits in old age has also been applied to the language production process and TOTs. This hypothesis aligns closely with the cause of TOTs as alternate words that block retrieval. If inhibitory processes are less efficient in old age, older adults who have more TOTs should also be more likely than younger adults to have an alternate word in mind during a TOT, which caused the TOT.

Brown and Nix (1996) supported this prediction, where older adults recorded having more incorrect alternates come to mind during a TOT than young adults, many of which shared partial phonology with the target. However, older adults also reported *less* phonological information during a TOT, which seems inconsistent with the idea that phonologically-similar alternates are causing TOTs. If older adults can activate an alternate's phonology more than younger adults, then they should be able to activate some of the target's phonology as well. A plethora of empirical evidence has emerged to demonstrate that older adults typically produce *fewer* alternates during a TOT compared to young adults, which is more congruent with

the interpretation that older adults have a general impairment for retrieving phonological information (Burke et al., 1991; Burke & Shafto, 2004; Fraas et al., 2002; White & Abrams, 2002). However, alternates have been shown to play a role in resolving TOTs for both young and older adults (e.g., Burke et al., 1991; see also Burke & Shafto, 2004, for a review). When TOT states were accompanied by an alternate word, they were less likely to be resolved. Furthermore, even when resolved, retrieving the intended word took longer relative to TOT states that occurred without alternate words in mind, and this delay in TOT resolution was more pronounced for older adults than young adults. Thus, it seems that there are some circumstances under which alternate words can function to compete for retrieval, especially for older adults, but not in general as suggested by IDH.

Factors Affecting TOT Incidence

Examining TOT incidence usually involves manipulating certain characteristics of the target TOT words (e.g., word frequency; Harley & Bown, 1998) or the conditions under which a TOT is elicited (e.g., after a list of phonologically-related words has been presented; Rastle & Burke, 1996). Regardless of the specific manipulation, the aim of experiments investigating TOT incidence is to examine which factors make TOTs more or less likely to occur. Studies that also include age have attempted to identify which factors have a more pronounced effect on older adults' TOTs. Overall, research on TOT incidence has been illustrative not only in demonstrating the conditions under which speech production processes are prone to failure but also in identifying how the magnitude of these influences change with age. Specific factors that have been studied in conjunction with aging are: (1) word frequency, (2) neighborhood density and frequency, (3) first-syllable frequency, (4) priming of TOT incidence, using phonological primes and semantic primes, and (5) proper name status.

TDH provides a framework for understanding how these factors might affect TOT incidence by elucidating their impact on a to-be-retrieved target's lemma-to-phonology connections. Specifically, factors that strengthen those connections should decrease TOTs, whereas factors that weaken those connections should increase TOTs. Strengthening/weakening of these connections is directly proportional to the use of the target word's phonology. The factor of word frequency serves as a measure of connection strength such that high-frequency targets have stronger connections, whereas low-frequency targets have weaker connections. The factor of phonological priming involves recent presentation of words containing the target's phonology, which serves to temporarily strengthen the target's lemma-to-phonology connections relative to (a) targets whose phonology was not accessed recently, and (b) semantic primes, words that strengthen conceptual availability. The factor of proper name status in TDH is represented by names having an additional layer of lemma-to-phonology connections (between a person's full name and each individual name, i.e., first and last name), which makes names more susceptible to TOTs than other types of words.

Connection strength is also influenced indirectly by the phonological relatedness of words associated with a target. Specifically, the factors of neighborhood density, neighborhood frequency, and first-syllable frequency tell us about the number of words that are phonologically connected with a target (i.e., "neighbors"), as well as how frequently those phonologically-related words are used in speech. Because TDH assumes that activated phonological segments send bottom-up feedback activation back up to all associated lemmas, a target that shares phonological connections with many words and/or high-frequency words consistently receives more bottom-up activation and will consequently have stronger lemma-to-phonology connections, relative to targets that are phonologically related to only a few words and/or low-

frequency words. In other words, usage of connections relevant to the target's phonology can influence TOTs for that target.

With respect to aging, MacKay and Burke (1990) proposed that the process of strengthening existing connections is age invariant, which implies that young and older adults will benefit similarly from factors that strengthen lemma-to-phonology connections. Conversely, older adults' transmission deficits may make them more susceptible than young adults to factors that weaken lemma-to-phonology connections. More generally, TDH provides an architecture where phonologically-related words can either increase or decrease older adults' TOTs. In contrast, IDH does not offer a scenario where phonologically-related words will have a facilitative effect for older adults.

Word frequency. *Word frequency* is a measure of how often a word is used in spoken or written language. In Brown and McNeill (1966), TOTs were elicited by presenting definitions for words with low frequency of use (e.g., *apse*, *nepotism*, *cloaca*, *ambergris*, and *sampan*), as there were anecdotal suggestions that these types of words would be likely to induce TOTs. Theoretical accounts like TDH also suggest that infrequently-accessed words do not regularly send activation from their lemmas to their associated phonology, thereby making these connections weaker and more susceptible to TOTs. Harley and Bown (1998, Experiment 1) empirically manipulated word frequency by using definition questions whose answers were designated as either high- or low-frequency as categorized by the Oxford Psycholinguistic Database (Quinlan, 1992), a database which contained (among many other psycholinguistic variables) frequency measures that were adopted from an original corpus compiled by Francis and Kucera (1982). As expected, participants in Harley and Bown's experiment were more likely to have TOTs for low-frequency words as opposed to high-frequency words.

Burke et al. (1991, Experiment 1) investigated word frequency naturalistically in a four-week diary study where young and older (mean age 71) participants recorded their TOTs. Resolved TOTs were retroactively categorized in terms of word frequency, using the Francis and Kucera corpus. The median word frequency of TOTs was significantly lower that what would be expected by chance. Furthermore, the majority of reported TOTs (47%, excluding non-normed proper names) in Burke et al. (1991) were words that were so infrequently used that they did not appear in Francis and Kucera's corpus, and a marginal trend indicated that older adults produced slightly more of these "unlisted" words than young adults. This suggested that while low-frequency words are generally more susceptible to TOTs, this might be exacerbated in older adults. These studies converge to support the argument that infrequently used words have inherently fragile connections between their lemmas and phonology and are therefore more prone to TOTs, an effect that may be compounded by aging.

Neighborhood density and frequency. Another factor related to TOT incidence is *phonological neighborhood density*, the number of words that phonologically resemble a given target word (e.g., *pint* has phonological neighbors that include words like *pant, pine,* and *punts*). Whereas IDH predicts an inhibitory effect of neighborhood density on TOT incidence because highly dense neighborhoods contain a greater number of potential phonological competitors, TDH predicts a facilitative effect of high neighborhood density on TOT incidence because of feedback (bottom-up) activation transmitted from neighbors' phonology to associated lemmas. For example, when a target word that has many neighbors becomes activated (e.g., *taper*), its lemma transmits activation to its phonological nodes, which in turn feed activation back to all lemmas that possess some of that phonology (e.g., the lemmas for *tailor*, *tame*, *paper,* etc.). Now those lemmas transmit activation back down to their phonological nodes, which strengthens the

shared connections to the target's phonological nodes and makes a TOT less likely to occur. Words with few neighbors receive little feedback activation, making their lemma-to-phonology connections comparatively weak and more vulnerable to TOTs.

Research has supported TDH's prediction, demonstrating that words with denser neighborhoods are less susceptible to TOTs. Harley and Bown (1998, Experiment 1), who found that low-frequency words induced more TOTs than high-frequency words in young adults, also manipulated neighborhood density, such that within the high- and low-frequency groups, half of the words had high phonological density, and half had low phonological density. Words with lower neighborhood density (fewer phonological neighbors) resulted in more TOTs than those with higher neighborhood density (more phonological neighbors). They also found that neighborhood density interacted with word frequency such that the effect of neighborhood density was greater for low-frequency words than high-frequency words; specifically, low-frequency words that were also low in neighborhood density produced the greatest number of TOTs, which suggests that multiple lexical factors can have an additive effect on increasing TOTs.

Vitevitch and Sommers (2003) used a similar methodology to Harley and Bown (1998), i.e., eliciting TOTs via definition questions (Experiments 1 and 2), but they manipulated *neighborhood frequency* as well as density and compared young and older adults. Neighborhood frequency refers to the mean word frequency of associated phonological neighbors; words with low neighborhood frequency have phonological neighbors that are low in frequency of use on average, whereas words with high neighborhood frequency have neighbors that are relatively high in frequency. Results from young adults replicated Harley and Bown's (1998) results with respect to word frequency and neighborhood density, but young adults were unaffected by

neighborhood frequency. In contrast, older adults' (mean age 70) TOTs were influenced interactively by word frequency, neighborhood density, and neighborhood frequency: Older adults reported more TOTs for words with low neighborhood frequency (compared to words with high neighborhood frequency), but only when the target also had low neighborhood density or low word frequency. Why were older but not young adults affected by neighborhood frequency? Because young adults have stronger connections between lemmas and their phonology than older adults, young adults can receive feedback activation from phonological neighbors regardless of whether those neighbors are high or low frequency. However, older adults can only receive feedback activation from high-frequency phonological neighbors, as connections to low-frequency neighbors are too degraded to provide any feedback (Vitevitch & Sommers, 2003).

First-syllable frequency. Like neighborhood frequency, a target's *first syllable frequency* also affects TOT incidence, but again only in older adults (Farrell & Abrams, 2011). First syllable frequency refers to the degree of usage of that particular syllable within the language. A word with high first syllable frequency possesses a first syllable that occurs in many words (e.g., /dɪ/, as in *decanter*, *deceased*, *debate*, and many others), whereas a word with low first syllable frequency has a less commonly used first syllable (e.g., /ɒm/ as in *omnivore* and *omniscient*, not many others). Farrell and Abrams examined TOT incidence as a function of target words' first syllable frequency in three age groups. First syllable frequency (high or low) was categorized independently from word frequency, as all targets were low-frequency words. Whereas college-aged participants' TOT rates were unaffected by the target's first syllable frequency, both groups of older adults experienced a first syllable frequency effect on TOT incidence, with more TOTs occurring for targets with low-frequency first syllables than high-frequency first syllables, and

this effect was greater for old-old adults (mean age 80) than young-old adults (mean age 68). This greater influence on first syllable frequency in older adults also impacted age differences in TOT incidence, such that old-old adults experienced more TOTs than the other groups only when the targets possessed low-frequency first syllables; TOT rates were equivalent for the three groups when targets contained high-frequency first syllables. Because older adults' connections to syllabic representations are weakened, the infrequency with which low-frequency syllables are produced creates an additive, negative effect for older adults that increases their susceptibility to TOTs, similar to the effects of neighborhood frequency. Conversely, having a large number of words that share a particular syllable offsets the weakening that results from aging, as the higher frequency with which that syllable is encountered strengthens its connections with all lemmas containing that syllable and decreases the likelihood of a TOT occurring (Farrell & Abrams, 2011).

In sum, these experiments on factors described so far indicate that TOTs are not only influenced by certain properties of the TOT word in question (e.g., word frequency) but are also influenced indirectly by other words that are phonologically related to the target. Moreover, it seems that older adults are particularly sensitive to the ways in which these factors interact and influence one another.

Phonological priming. Because TOTs are presumed to result from a failure to encode the phonology of the correct target word, and also because TOTs are generally more frequent for words that have not been used recently, it is logical to predict within TDH that strengthening the connections between a word's lemma and phonology will reduce the likelihood that TOTs will occur. Rastle and Burke (1996) systematically tested this assumption by employing a repetition priming procedure, i.e., presenting a target word in an earlier task and then seeing if this recent

presentation reinforced the phonological connections for that target and reduced its susceptibility to a future TOT. They exposed young and older adult (mean age 70) participants to a target's phonology by having them read aloud a list of words (the majority of which were nouns, and some of which were proper names) and rate each word for "pronunciation difficulty". Following a ten-minute delay, participants were presented with a set of general knowledge questions, where half of the target answers were words/names read previously (i.e., primed) in the pronunciation task, and they indicated whether they knew the answer, did not know the answer, or were having a TOT. Consistent with prior research, TOTs were more prevalent for older adults, and proper names accounted for the majority of these TOTs. With respect to phonological priming, both age groups experienced a reduction in TOT incidence for targets that were recently produced in the pronunciation task relative to non-recently presented targets, demonstrating priming of TOT incidence as predicted by TDH.

James and Burke (2000, Experiment 1) also investigated the facilitative effect of strengthening of phonological connections on TOT incidence but conclusively demonstrated that phonological overlap was solely responsible for these effects. Because Rastle and Burke (1996) had participants produce the identical word prior to administering the TOT-inducing task, their prime overlapped not only phonologically but also lexically and semantically with the target (because they were the same word). James and Burke distributed the phonological segments of each target word over a sequence of prime words that cumulatively contained the target's syllables (e.g., presenting *ab*stract, *in*digent, *trun*cate, *tra*dition, and *lo*cate when the TOT target was *abdicate*). For each target, young and older adults (mean age 72) were presented with either a primed list (where half of the words shared partial phonology with the intended TOT target word as illustrated above) or an unrelated list of words. After saying each word aloud and rating

it for pronunciation difficulty, the general knowledge question was presented, to which participants attempted to retrieve the target. Prior production of the target's phonology, which occurred only when reading primed lists, reduced TOT incidence relative to words in the unprimed lists, and the priming effects were equivalent for both age groups. These findings demonstrate that not only can TOTs be offset by recent presentation of a word's phonology, which presumably strengthens the weakened lemma-to-phonology connections that cause TOTs, but that even older adults can benefit from this exposure.

Burke et al. (2004, Experiment 1) focused specifically on phonological priming on TOT incidence for proper name targets (e.g., *Brad Pitt*), using a picture naming task to induce TOTs. Young and older adults (mean age 72) began each trial by producing the answer to a fill-in-the-blank statement, where the correct answer was either a homophone of the target name (e.g., *pit*) or a non-homophone (e.g., *cane*). After a delay consisting of an intervening filler picture and filler question, the target picture was presented, and participants were instructed to produce the entire name of the person. Prior production of a homophone decreased TOTs for names corresponding to the other spelling of the homophone for both age groups; however, when participants who demonstrated awareness of the phonological relationship between the initial homophone sentence and the target picture were excluded, only older adults exhibited this priming effect. This age-linked asymmetry in phonological priming of TOT incidence, where older adults benefitted *more* than young adults from the strengthening of connections caused by production of the homophone, seems to be linked to older adults' increased difficulty in retrieving proper names relative to object names. The paucity of semantic connections for proper names in conjunction with the age-related weakening of connections allows older adults to

benefit more from phonological input, consistent with the claim that aging is a unique and independent factor contributing to retrieval failures.

Semantic priming. While TOTs reflect a failure to encode the appropriate phonology of a word, individuals generally have sufficient access to semantic (conceptual) information relevant to the intended word (e.g., Burke et al., 1991; Dell, 1986; Levelt, 1989). It is therefore unsurprising that semantic priming has had little effect on TOT incidence. While Rastle and Burke (1996) found advantages for prior processing of phonological information in terms of reducing TOTs, they found that asking participants to first rate how pleasant each of the words were (semantic processing), prior to retrieving them from definition questions, did not provide any extra advantage in reducing TOTs above and beyond simply reading the phonology of the TOT word. Cross and Burke (2003) showed that the lack of facilitation from prior processing of semantic information on TOT incidence also occurred for proper names. In this experiment, young and older adults (mean age 72) were first asked a question about a famous character (e.g., *Eliza Doolittle)*, were subsequently shown a picture of the person depicting that famous character (e.g., a picture of *Audrey Hepburn* portraying *Eliza Doolittle*), and were asked to produce the name of the portrayer (e.g., *Audrey Hepburn*). Neither young adults nor older adults experienced a reduction in TOTs, suggesting once again that prior presentation of semantically-relevant information did not strengthen connections between lemmas and phonological information, which are critical for reducing TOTs. Farrell (2012, Experiment 2) compared semantic priming of TOT incidence for both names and nouns. Young and older (mean age 69) participants answered either a prime question containing a word semantically related to the target (e.g., *vegetarian*) or an unrelated question, then attempted to produce the target (e.g., *herbivore*) in response to its question. She found no effect of semantic priming on TOTs for either type of

word or for either age group, consistent with the idea that TOTs are linked more strongly to activation of a word's phonology than its semantics. Once again, these effects are contrary to those expected from the perspective of IDH, which would predict greater interference from semantic competitors, and likewise, more TOTs.

Name status. The retrieval of proper names has been of particular interest in aging research because names are specifically susceptible to retrieval failures compared to other types of words (e.g., nouns), even for younger adults (e.g., Brédart & Valentine, 1998; Evrard, 2002; Young, Ellis, & Flude, 1988; but see Hanley, 2011, Maylor, 1995, 1997, and Rendell, Castel, & Craik, 2005). Memory for proper names is typically poorer than memory for other descriptive, conceptual information (like a person's occupation; Barresi, Obler, & Goodglass, 1998), even when a proper name is phonologically identical to a particular descriptor. For example, it is easier to remember that a person *is* a baker than to remember that his name is Mr. Baker (an effect appropriately termed the "Baker-baker" paradox; e.g., Cohen & Faulkner, 1986; McWeeny, Young, Hay, & Ellis, 1987). This disparity for proper names being more difficult to remember than other types of information is even more pronounced in older adults, evidenced by TOTs. Although older adults experience more TOTs than young adults for all types of words, they have disproportionately more TOTs for proper names (e.g., Burke et al., 1991; Cohen & Faulkner, 1986; Evrard, 2002; Farrell, 2012; James, 2004, 2006; Juncos-Rabadán, Facal, Rodríguez, & Pereiro, 2012).

***Explanation for the Vulnerability of Proper Names*.** What mechanisms are responsible for making proper names specifically susceptible to retrieval failures and for disproportionately impairing their retrieval in old age? A number of possible explanations have been proposed. One possibility is that names have impoverished semantic associations, which make them more

difficult to encode in and subsequently retrieve from memory (e.g., Fogler & James, 2007). While non-name nouns (e.g., *dog*) are associated with a global, consistent set of semantic traits by which individuals develop schemas (e.g., a *dog* has fur, four legs, and barks), proper names are associated with a very limited and specific set of semantic criteria that varies from individual to individual (e.g., not every person named *John Smith* will be a lawyer). Anecdotally, we know from our everyday experiences that many people can share a name without necessarily having any features in common. It is likewise difficult to predict what a person is like simply based on their name, except perhaps in the case of nicknames, where a name is derived from a physical feature or personality characteristic (e.g., *negative Nancy).* Without an established semantic network, i.e., a consistent set of factual information, proper names act almost exclusively as meaningless labels that do not provide any substantive information about their associated referent (Brédart & Valentine, 1998; Brédart, Valentine, Calder, & Gassi, 1995; Evrard, 2002; Semenza, 2006, 2009).

This claim can be further illustrated by the Baker-baker paradox. The noun *baker* likely conjures images consistent with its definition, such as someone making bread or other baked goods, wearing a white hat, or covered in flour. These descriptors facilitate and enrich the encoding process, permitting us to more easily integrate the word *baker* into an existing semantic network and making the word easier to retrieve later (e.g., Cohen & Burke, 1993; Cohen & Faulkner, 1986). However, *Mr. Baker* does not evoke any especially descriptive characteristics (because the name itself is not associated with a specific semantic network), nor does it explicitly relay anything meaningful about the person's profession or image, aside from perhaps suggesting gender and in some cases nationality. Fogler and James (2007) extended the examination of name arbitrariness/descriptiveness to the context of aging, where young and older adults (mean

age 71) were presented with pictures of well-known cartoon characters with either descriptive names (e.g., *Snow White*) or non-descriptive names (e.g., *Charlie Brown*). As expected, both young and older adults experienced greater difficulty retrieving non-descriptive names than descriptive names, but older adults experienced significantly more retrieval failures for non-descriptive names than young adults.

In addition to semantic deficiencies, other influences at the lexical- or phonological-levels may make proper names more difficult to retrieve than other classes of words. For example, proper names (unlike nouns) do not have synonyms that can be used when the target word is temporarily inaccessible (e.g., Brédart, 1993); the terms *insect*, *butterfly*, and *monarch butterfly* can all be used to refer to the same object, whereas there is only one specific name (*Barack Obama*) for the current president of the United States. Because effective production of proper names requires the activation of a single correct name phrase, retrieval failures are not only more likely to occur (as a single deficient connection could lead to a retrieval failure), but it also makes proper name retrieval failures more noticeable because a name cannot be substituted for another word (e.g., James, 2004).

Additionally, proper names typically have multiple phonological components that make up the name phrase (one first name and one last name, and sometimes even a middle name), whereas nouns frequently only have one (see Figure 1). Within TDH, proper names are associated with increased TOTs because of these additional connections that are susceptible to weakening, i.e., individual connections between the lemma for the full name (*Brad Pitt*) and its corresponding first (*Brad*) and last (*Pitt*) name (e.g., Burke et al., 2004; Burke et al., 1991). When more phonological components are needed to retrieve the entire name phrase, there are correspondingly more opportunities for retrieval failures to occur, which explains why

individuals tend to have more TOTs for targets who are known by three names (e.g., actor *Sarah Jessica Parker*) as opposed to just two (*e.g.*, actor *Julia Roberts*; Hanley & Chapman, 2008; Stevenage & Lewis, 2005). Proper names are also generally accessed less frequently than nouns; even the most common names, like Smith, are accessed less often than other types of words, which makes the connections among conceptual, lexical, and phonological information within the proper name hierarchy comparatively weak and more prone to retrieval failures (e.g., Burke et al., 1991; Cohen & Burke, 1993; Conley, Burgess, & Hage, 1999).

Taken cumulatively, the evidence presented here suggests that proper names' increased susceptibility to TOTs is due at least in part to the fact that proper names are relatively non-descriptive in nature, do not provide any helpful cues to aid retrieval, and do not fit neatly within a higher semantic network (unlike other types of words). During the natural aging process, opportunities for these already naturally-prevalent retrieval failures become even more frequent because the integrity of the language system is, at baseline, compromised. Further research is needed to understand the degree to which each of these factors contributes independently or additively to older adults' increased TOTs for proper names.

TOT Resolution

Although a considerably smaller literature relative to TOT incidence, the other focus of TOT research has been on the processes that underlie resolution of TOTs, i.e., subsequent retrieval of the intended word after a TOT occurs. The process of resolution can inform us about the weakened lemma-to-phonology connections that cause TOTs because successful resolution of a TOT suggests that these connections, initially weak enough to cause the TOT, have become strengthened, allowing the TOT word's phonology to accumulate a sufficient amount of activation that is necessary for retrieval. The most common method for resolution in people of all

age groups is spontaneous resolutions (e.g., Burke et al. 1991; Heine, Ober, & Shenaut, 1999), also called *pop-ups*, where the target word "pops into mind" when not explicitly paying attention to the TOT (Cohen & Faulkner, 1986; Reason & Lucas, 1984). However, older adults typically need more time to resolve their TOTs than younger adults (Burke et al., 1991; Heine et al., 1999; but see Brown & Nix, 1996). Measuring TOT resolution in the laboratory has typically involved a methodology (see Figure 2) where a general knowledge question is presented first. When a TOT occurs, either a primed list (containing words believed to influence resolution) or an unrelated list is shown, after which the TOT-inducing question is shown again. Priming is measured as the difference in TOT resolution following a list containing phonologically-related words relative to a list with solely unrelated words.

Using a priming technique offers a way to provide an alternate word of sorts and assess its effects on TOT resolution. As noted earlier, the presence of an alternate during a TOT delays TOT resolution and decreases the likelihood that the TOT will be resolved (Burke et al., 1991), suggesting that the alternate may be competing with the target for retrieval. Within IDH, this competition arises from older adults being less able to inhibit the alternate, suggesting that the presence of alternate words will be detrimental for TOT resolution under all circumstances. Within TDH, there are various factors that are likely to affect whether alternates compete with or facilitate TOT resolution, i.e., not all alternates will be competitors for retrieval. Research has explored three such factors and their interactions with age on TOT resolution: (1) phonological relatedness, (2) grammatical class, and (3) first-syllable frequency.

Phonological relatedness refers to a prime (alternate) that contains some or all of the target's phonology. Similar to its effect on TOT incidence, a phonologically-related prime presented during a TOT should strengthen the lemma-to-phonology connections that caused the

TOT and increase resolution, and both young and older adults should benefit similarly. However, phonological priming of TOT resolution may be moderated by the prime's grammatical class. Within TDH, grammatical class provides a constraint such that only one lexical node, the one accumulating the most priming, can be activated at a time (Burke et al., 1991; MacKay, 1987; MacKay & Burke, 1990). Therefore, having a phonologically-related alternate that is in the same grammatical class as the target should be detrimental to TOT resolution, as the alternate's activation level must subside before the target can be activated. It is possible that older adults will be more adversely affected than young adults by a same-grammatical class alternate and need more time for the target to accumulate sufficient priming, given their weakened connections to phonology. First-syllable frequency, independently and in conjunction with aging, could also play an inhibitory role in TOT resolution within TDH via competition from interconnected phonological representations. Upon presentation of the prime, its lemma will send activation to its phonological nodes, which in turn will transmit bottom-up activation to the other lemmas sharing that phonology. When there are many other possible lemmas (a high-frequency first syllable), there are more words to compete with the target for retrieval relative to when there are only a few other lemmas (a low-frequency first syllable). Again, the possibility arises that older adults may be particularly susceptible to these proposed first-syllable frequency effects on TOT resolution.

Phonological relatedness. James and Burke (2000, Experiment 2) were the first to make a causal link between phonological encoding processes and pop-ups. In addition to demonstrating that prior production of phonologically-related words reduces TOT incidence, they also showed that production of words that share phonology with the TOT word increases the likelihood of *resolving* the TOT. For example, after reporting a TOT for *abdicate*,

subsequently pronouncing a list of words that included *ab*stract, *in*digent, *trun*cate, *tra*dition, and *lo*cate resulted in more TOT resolution compared to when a list of unrelated words was presented. Both younger and older adults (mean age 72) exhibited significant priming of TOT resolution. James and Burke interpreted these findings as demonstrating a mechanism by which pop-ups occur: They are triggered when the TOT word's phonology is perceived or produced, which helps to strengthen the weakened phonological connections that caused the TOT in the first place.

Subsequent research has demonstrated that activating the initial syllable specifically is essential for TOT resolution (Abrams, White, & Eitel, 2003; White & Abrams, 2002). In these studies, the phonologically-related list of words presented during a TOT contained words with solely the first syllable, the middle syllable, the last syllable, or the initial phoneme/letter of the TOT word. TOT resolution was increased only following lists containing the first syllable, suggesting that TOT resolution cannot be facilitated if the TOT word's initial phonology remains unavailable. With respect to age-related differences in priming of TOT resolution, adults in their 60s and early 70s show priming of TOT resolution to the same degree as younger adults (e.g., Heine et al., 1999; James & Burke, 2000; White & Abrams, 2002; but see Abrams, Trunk, & Merrill, 2007). In contrast, adults in their late 70s and 80s have significantly less or no TOT resolution following phonologically-related words (e.g., Abrams et al., 2007; Heine et al, 1999; White & Abrams, 2002). These findings suggest that the severity of transmission deficits that cause TOTs continues to advance with increasing age within older adulthood and affect TOT resolution, similar to increases in TOT incidence (e.g., Heine et al., 1999).

Grammatical class. Recent research has documented several psycholinguistic factors that are relevant to phonological priming of TOT resolution as well as interactions with age. One

such factor is the prime's grammatical class, or part of speech. The relevance of part of speech can be observed in alternate words that sometimes accompany TOTs. Not only do alternates frequently share phonological features such as first letter and number of syllables with the intended target, but they also typically share syntactic features such as part of speech (e.g., Brown & McNeill, 1966; Burke et al., 1991; Miozzo & Caramazza, 1997). For example, in Burke and colleagues' (1991) four-week diary study of TOTs, alternates reported during TOTs were frequently the same part of speech as the target (85% of the time for young adults, 93% for older adults). This overlap with part of speech is interesting, particularly because the presence of alternates has a detrimental effect on TOT resolution in naturalistic studies: When TOTs are accompanied by alternate words, TOTs take longer to resolve and are less likely to be resolved than TOTs that occur without alternates (Burke et al., 1991). Together, these findings suggest that an alternate's grammatical class may be critical in determining when TOT resolution will occur.

Abrams and Rodriguez (2005) tested this idea via phonological priming of TOT resolution and found that a phonological prime's grammatical class plays a pivotal role in influencing TOT resolution in laboratory studies. Following a TOT (e.g., for *rosary*, a noun), participants pronounced aloud a list of words containing either a phonological prime with the same first syllable and same part of speech as the target (e.g., *robot*, which is a noun), a phonological prime with a different part of speech (e.g., *robust*, which is an adjective), or an unrelated word. They found that a phonologically-related word increased TOT resolution only when it was a part of speech different from the target. Phonologically-related words that were the same part of speech as the target had no effect, resulting in similar rates of TOT resolution to that following the unrelated word list.

Interestingly, these influences of grammatical class on TOT resolution were not uniform across the lifespan. Comparing younger adults and two groups of older adults, Abrams and colleagues (2007) found that adults aged 61–73 performed similarly to younger adults, showing phonological priming of TOT resolution only when the prime was a different part of speech from the target, although they exhibited priming to a lesser degree than younger adults, and no priming when the prime was the same part of speech as the target. In contrast, adults aged 75-89 did not get increased TOT resolution from either type of prime, and even more interestingly, they demonstrated an inhibitory effect on TOT resolution following a same part-of-speech prime: Their retrieval of the target was *worse* after reading the list containing the prime compared to the list with unrelated words. These findings suggest another difference that arises with advancing age: Alternates can become more competitive for retrieval during a TOT but only under specific circumstances. What is the possible mechanism that underlies this effect, since it cannot be explained solely by older adults having inefficient inhibitory processes as proposed by IDH? One possibility is that when the activation level of an alternate approaches or exceeds that of the TOT target, the alternate can become a competitor and delay TOT resolution (see Dell & Gordon, 2003, and Gordon & Kurczek, 2014, for related arguments regarding phonological neighborhood and speech production). The weakened lemma-to-phonology connections for the oldest adults are particularly susceptible, allowing an alternate to become competitive during a TOT, but only when the alternate shares the appropriate phonological and syntactic information of the target.

First-syllable frequency. Another factor shown to affect TOT resolution in younger and older adults is the target's first syllable frequency (Farrell & Abrams, 2011). Recall that first syllable frequency affected TOT incidence but only for older adults, such that both groups of older adults experienced more TOTs for words with a low-frequency first syllable relative to a

high-frequency first syllable. Interestingly, first syllable frequency had the opposite effect on TOT resolution, and it affected young and older adults similarly. When a phonological prime with the same first syllable as the target was presented during TOTs, all age groups *resolved* more TOTs for targets with a low-frequency first syllable, i.e., having a low-frequency first syllable was beneficial to target retrieval. Farrell and Abrams proposed that this reversal in the effect of first syllable frequency may be a function of competition that is initiated by the prime word, once in a TOT. The prime's first syllable transmits activation to the other lemmas sharing that syllable, so when there are many other possible lemmas (a high-frequency first syllable), there are more words to compete with the target for retrieval relative to when there are only a few other lemmas (a low-frequency first syllable).

Contrary to the competition created by alternates that share grammatical class (Abrams et al., 2007), the oldest adults in Farrell and Abrams (2011) did not experience greater competition than the other age groups from primes with high-frequency first syllables. One possible explanation is that the frequency of those non-presented competitors also plays a role in TOT resolution. It seems likely that the lemmas associated with a high-frequency first syllable may be higher in word frequency, making them competitive for all age groups because the target words that are susceptible to TOTs are generally low frequency. In any case, research on TOT resolution has demonstrated that there are specific age-linked changes to the utilization of phonological processes and that those changes are not uniform for older adults of all ages.

Proper Name TOTs in Alzheimer's Disease

Up to this point, the chapter has focused on the increase in TOTs as a function of normal, healthy aging. However, TOTs have also been a fruitful source of information regarding the progress of certain aspects related to pathological aging. For example, although general language

impairments have been reported in a variety of neurodegenerative diseases (e.g., semantic dementia; Reilly & Peele, 2008), proper name retrieval failures have been distinctively and consistently linked to AD and MCI, a pre-AD memory disorder classified by a range of clinical subtypes, which can convert to AD[1] (e.g., Estévez-González et al., 2004; Juncos-Rabadán, Facal, Lojo-Seoanne, & Pereiro, 2013a; Risacher et al., 2009; Semenza, Borgo, Mondini, Pasini, & Sgaramella, 2000; Semenza, Mondini, Borgo, Pasini, & Sgaramella, 2003; Thompson, Graham, Patterson, Sahakian, & Hodges, 2002). Research has attempted to explain proper name retrieval failures in terms of the asymmetric degradation of the brain during the course of AD. Unlike other brain injuries that result from an immediate focal lesion (e.g., stroke), AD has an insidious onset that typically begins with atrophy in the medial temporal lobe (e.g., Barbeau et al., 2008; Barkhof et al., 2007; Jacobs et al., 2011; Visser, Verhey, Hofman, Scheltens, & Jolles, 2002), with the development of neurofibrillary tangles in subhippocampal regions such as the perirhinal and entorhinal cortices that are important for memory retrieval (Delacourte et al., 1999). This early atrophy also extends to anterior temporal regions (McDonald et al., 2009), which together form the *anterior temporal network* (ATN; consisting of the hippocampus, temporal pole, uncus, and the enthorinal/perirhinal cortices; Gour et al., 2011, Kahn et al., 2008), before slowly progressing to more posterior, neocortical regions (see also Braak & Braak, 1991, for a description of Alzheimer's stages). The result is a disease whose symptoms emerge slowly, sometimes unnoticeably, and become progressively more malignant and apparent (e.g., Longley & Warner, 2002).

The fact that AD seems to initially target regions in the ATN is particularly relevant for the retrieval of proper names, as some recent research indicates that the left anterior temporal regions (namely, the temporal pole) may be more involved with storage and retrieval of proper

[1]See Fischer et al. (2007) for an empirical comparison between MCI subtypes, and Petersen (2003) for an overview.

names compared to other types of words (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Gorno-Tempini et al., 1998; Semenza, 2011). Specifically, it has been suggested that the temporal pole helps to mediate *phonological* retrieval processes necessary for name articulation in conjunction with other perisylvian structures (e.g., Damasio & Damasio, 1994; Juncos-Rabadán et al., 2011; Proverbio, Lilli, Semenza, & Zani, 2001). The temporal pole has also been suggested to be involved with the retrieval of person-specific *semantic* information (Brambati, Benoit, Monetta, Belleville, & Joubert, 2010), supported by connections to medial structures that are important for memory retrieval like the entorhinal cortex and hippocampus (Arnold, Hyman & Van Hoesen, 1994; Ding, Van Hoesen, Cassell, & Poremba, 2009; Guedj et al., 2010; Juncos-Rabadán, Rodríguez, Facal, Cuba, & Pereiro,2011; Muñoz & Insausti, 2004; Vorobyov & Brown, 2008). Alternatively, storage and retrieval of other types of words may rely on a more distributed neural network (Proverbio et al., 2001; Warburton, et al., 1996; see also Martin, 2007, for a review), which may not be so locally impacted in early AD. Thus, it follows that pathological degradation to these parts of these anterior and medial temporal regions may specifically hinder proper name retrieval in AD, compared to the retrieval of other types of words (e.g., Semenza et al., 2003). In the following sections, we will examine research that demonstrates how AD increases the likelihood of proper name TOTs, both in terms of increasing transmission deficits during phonological retrieval and, more gradually, reducing access to relevant semantic information.

When examining phonological access impairments experienced by multidomain MCI patients, Juncos-Rabadán and colleagues (2011) eloquently described the role of the temporal pole as "a mediational structure that is engaged by those structures that guide the implementation of process of phonological representation in vocalization (supported by left temporal perisylvian

language areas)" (p.650). The fact that the anterior temporal lobe/temporal pole is considered to be at least partially involved in proper name phonological retrieval is notable because it interfaces with what is already known about the cognitive mechanisms of proper name TOTs: Age-related decline contributes to a weakening of the connections between proper name lemmas and associated phonological nodes. However, the atrophy resulting from AD is far more severe than the gradual neuronal degradation that would be expected during the normal aging process, even in early or moderate stages of the disease (e.g., Jack et al., 1997; Jacobs et al., 2011). From the perspective of TDH, this has been interpreted to mean that the connections between lemmas and phonological nodes in AD patients are significantly more degraded than those in healthy older adults (e.g., Juncos-Rabadán et al., 2011). This helps to explain why AD patients report more proper name TOTs than healthy older adult controls, and also why these TOTs become more prevalent as atrophy spreads and the brain becomes increasingly deteriorated (e.g., Delazer et al., 2003; Juncos-Rabadán et al., 2013a; Juncos-Rabadán, Facal, Logo-Seoane, & Pereiro, 2013b; Juncos-Rabadán et al., 2011).

Some behavioral research has extended these claims of disproportionately impaired phonological access in AD by examining the amount of phonological information that AD patients have available during a proper name TOT. For example, a celebrity face-naming study by Delazer and colleagues (2003) found that relative to healthy controls (mean age 72) and high-functioning older adults with MCI, AD patients (mean age 73) were less likely to provide pertinent phonological information (e.g., first phoneme or syllable) during a TOT when probed, and they also did not benefit as much from phonological cuing (i.e., retrieving the name after partial phonology was supplied). Overall, evidence seems to suggest that the increase in proper name TOTs for AD patients is at least partly related to severely compromised connections

between lemmas and associated phonological nodes, exaggerated by disproportionate atrophy in the temporal regions of the brain.

Furthermore, the fact that the anterior temporal lobe/temporal pole is considered to be involved in proper name retrieval introduces another important factor that distinguishes healthy older adults from AD patients: Disproportionate impairments in retrieving semantic information related to proper names. For example, in a fMRI study, Brambati and colleagues (2010) asked participants to classify individuals based on occupation and found that the anterior temporal lobe was indeed involved with retrieving person-specific semantic information. Behavioral research (e.g., Delazer et al., 2003; Hodges, Salmon, & Butters, 1993) has complemented these fMRI data, demonstrating that AD patients produce significantly less biographical information (e.g., details relating to a person's occupation) relative to healthy older adult controls, possibly as a result of decreased integrity of regions in the ATN network. This is a fairly idiosyncratic symptom of AD because, as previously mentioned, healthy older adults are generally able to produce sufficient semantic information when experiencing proper name TOTs (e.g., Cohen & Faulkner, 1986). To examine this disparity, Beeson, Holland, and Murray (1997) compared adults suffering from mild AD (mean age 78), moderate AD (mean age 76), and healthy older adults suffering only from linguistic impairments (various forms of aphasia, with otherwise intact memory; mean age range 61–72) on proper name TOT incidence using a celebrity face-naming task. They found that when asked to produce biographical information during TOTs, all AD patients demonstrated a semantic deficit by producing less biographical information (e.g., the person's occupation) than older adults without AD, with the greatest deficit for the moderate AD group. Even when AD patients produced semantic information, it was less rich and detailed than healthy older adults (e.g., describing Bing Crosby as dead as opposed to a more distinct

characteristic, like singer). Similarly, Delazer and colleagues (2003) found that during a TOT, AD patients produced significantly less biographical information in response to semantic questions about celebrity faces (e.g., *What was the profession of this person before he became very famous?)* than healthy controls or high-functioning adults with MCI, who did not differ.

Why are results about semantic retrieval relevant to proper name TOTs in AD? Recall that within TDH, semantic access is relatively preserved in healthy aging because of an architecture where multiple semantic nodes can converge to activate a lemma and offset transmission deficits in any one connection (e.g., Burke et al., 1991; MacKay & Burke, 1990). As semantic information begins to erode in AD from disease-related anterior and medial temporal atrophy, the once-resilient architecture of the semantic system becomes damaged such that fewer semantic nodes become activated to converge on a specific lemma (e.g., Astell & Harley, 1996). This theoretical explanation would also suggest that top-down transmission of activation from conceptual to phonological levels is generally less effective (e.g., Greene & Hodges, 1996), meaning TOTs are more likely to occur. Thus, although semantic deficits for proper names might not emerge in the earliest stages, such deficits are certainly a hallmark symptom of AD that becomes quite distinctive as the disease progresses. These deficits are also a relevant factor in influencing proper name TOT incidence in AD.

Discriminating Normal from Pathological Decline. Knowing that effects of both semantics and phonology influence TOTs in AD is helpful in gauging the long-term trajectory of memory decline, but the question still remains: Is there a way to efficaciously discriminate the point at which proper name retrieval failures are no longer due to normal age-related decline, but rather, *early* stages of AD? Intuitively, it would seem that measuring participants' access to phonological information may be the most informative early diagnostic measure because

semantic deficits sometimes become evident only after the disease has become advanced. Research investigating proper name retrievals for older adults with MCI, who are sometimes at risk of developing AD, has proven to be a crucial source of valuable information for addressing this question. Whereas Delazer and colleagues (2003) did not find any differences in phonological access for MCI and healthy control groups during TOTs, they acknowledged that the MCI groups were very high-functioning (only differing from controls in one measure, verbal memory) and were primarily classified on the basis of self-reported memory problems, which might have been prone to bias. In a later experiment, Juncos-Rabadán et al. (2011) compared healthy older adults[2] with normal cognitive functioning to older adults with MCI (whose condition was not self-reported but instead confirmed via neuropsychological tests, like the Mini-Mental Status Exam; Folstein, Folstein, & McHugh, 1975) who had moderate cognitive deficits (consisting of two subgroups, multidomain amnestic and amnestic; mean age 71 and 68, respectively). They demonstrated that one subgroup of adults with MCI (multidomain amnestic) experienced more proper name TOTs in a face-naming task in addition to reduced access to phonological information during a TOT, but had sufficient access to semantic information like healthy controls (e.g., they were able to produce biographical information about the TOT target when asked).

These results were replicated in a second study by Juncos-Rabadán and colleagues (2013a), who followed up two years later with the same tasks and similar clinical populations (multidomain and single-domain amnestic patients, who were combined into a single MCI group), and then again in a third study (2013b) that included slightly different MCI clinical populations (multidomain amnestic and nonamnestic). In each study, the MCI groups

[2]Healthy older adults were split into two groups based on subjective complaints about memory: those with low memory complaints (mean age 68) and those with high memory complaints (mean age 67). The two groups exhibited equivalent functioning on all tasks and are combined together here for simplicity.

consistently exhibited greater phonological retrieval difficulties relative to healthy control populations while experiencing TOTs. Furthermore, there were no differences between multidomain amnestic and nonamnestic groups, as both were equally poor at retrieving phonological information during a TOT. Juncos-Rabadán and colleagues (2013a, 2013b) interpreted these results to suggest that disproportionate phonological deficits may be the earliest signs of neurodegenerative decline, resulting from reductions in cognitive resources and functioning needed to successfully retrieve phonology. Degraded access to phonology is followed later by additive deterioration of semantic access in the progression to AD. Therefore, the first steps in distinguishing healthy controls from MCI (and possibly early stages of other neurodegenerative diseases) might be to establish a threshold for "healthy" access to phonological information in order to confront potential diseases as early as possible, in addition to other classical measures that are employed to detect a decline in cognitive functioning (e.g., attention, executive function/working memory, etc.).

Extant research comparing AD patients and healthy aging adults has been critical in making progress toward defining a specific threshold of proper name retrieval failures that can be used for early detection. Because proper names are firstly and most noticeably affected in AD, moreso than in healthy aging, diagnostic batteries might benefit by including proper names retrieval failures in some way as a potential first indicator of pathological decline (instead of only including nouns, which are not a very sensitive early indicator of AD; e.g., Semenza et al., 2003). While a few new cognitive tests have been developed to include proper names as a diagnostic tool for such neurodegenerative diseases (e.g., the *Memory for Proper Names* task; Brouillette et al., 2011), these tasks primarily observe naming accuracy and retrieval of biographical information, not TOT rates, despite how useful proper name TOTs might be as

diagnostic criteria. However, it should be acknowledged that there are considerable difficulties to overcome in devising a clinical tool to test proper name TOT incidence, not the least of which is controlling for familiarity of the TOT questions; whereas familiarity with nouns, adjectives, or verbs are maintained across multiple generations, proper names are subject to fluctuating popularity even within a single cohort. Additional constructs would be necessary to verify knowledge of the proper names, and the TOT battery would almost certainly require frequent revisions.

In addition to aiding early diagnosis of AD, there is still much to explore to fully understand the nuances of proper name TOTs as a function of neurocognitive decline. Expanding research on healthy age-related changes in lexical retrieval and TOTs is still necessary for establishing a comprehensive, normative baseline of impairment, which can then be used as a model to identify early signs of pathologically-induced cognitive decline. Furthermore, research still needs to more finely discriminate symptoms between different types of neurodegenerative diseases. Even though AD is the most common form of dementia (NINDS, 2013), there are also several other types of dementia with differing etiologies and symptoms (e.g., Parkinson's disease, frontal variant dementia, semantic dementia, and MCI; see Reilly, Troche, & Grossman, 2011, for a review). Future research would benefit from understanding how/if language impairments, such as proper name retrieval failures, in each of these diseases uniquely differ from healthy adults, which will aid in early and appropriate diagnosis.

Current and Future Directions

Some researchers have highlighted the importance of using appropriate methodological and/or statistical controls before drawing conclusions about age differences in TOTs (Bahrick, Hall, & Baker, 2013; Gollan & Brown, 2006). Gollan and Brown (2006) proposed a new method

for calculating TOT incidence that accounts for retrieval failures at different stages: (1) "Step 1" failures, which are failures to activate the target word's lemma (and thus no opportunity to experience a TOT), and (2) "Step 2" failures, which are failures to activate the target's phonological representations after successful lemma activation, i.e., TOTs. They argued that TOTs should be calculated as the number of Step 2 failures divided by the number of Step 1 successes, a proportion that indicates the likelihood of a TOT under conditions where a TOT was possible. With respect to aging, they proposed that these calculations more appropriately take into account older adults' greater experience with words, which results in more opportunities for TOTs to occur, specifically for difficult words.

Bahrick, Hall, and Baker (2013) proposed that age comparisons in recall must first equate the availability of content, i.e., determine which information is equivalently recognizable by both age groups. They developed the accessibility/availability ratio, which provides an estimate of the proportion of available (recognized) memory targets that are also accessible (recalled), and they computed this ratio for younger and older adults' recall of famous names and low-frequency vocabulary words. Using this ratio, they found that only names, not vocabulary words, were more difficult to retrieve for older than younger adults. These findings are not a result of age differences in familiarity with those names (as measured by recognition on a multiple-choice test), which was controlled for. Thus, name recall is disproportionately affected in aging, and future research should continue to document factors that can help to reduce or minimize this disproportionate age impairment.

Farrell (2012) discovered one such factor specific to TOT incidence: first syllable frequency. Younger and older adults read general knowledge questions whose target answers were famous names or low-frequency nouns, both of which had first syllables that were

categorized either as high- or low-frequency. Consistent with older adults having greater impairment in name retrieval, older adults had more TOTs than young adults for both types of targets, but this age difference was greater for proper names than nouns. However, this disproportionate age deficit occurred only when targets had high-frequency first syllables. For targets with low-frequency first syllables, the age difference were similar for proper names and nouns. These patterns of findings remained when comparing a subset of names and nouns that possessed the identical first syllable, eliminating the possibility that names and nouns having different first syllables contributed to these findings. The other interesting finding was that only older adults demonstrated opposing influences of syllable frequency, where targets with high-frequency first syllables (compared to low-frequency first syllables) resulted in fewer TOTs for nouns but *more* TOTs for names. This influence of high first syllable frequency having a negative effect on production is unique, suggesting that for older adults, having many phonologically-related options can create interference or competition with the target when attempting to retrieve names specifically. Phonologically-related names can all be possible candidates for production (is it *Jennifer*, *Jessica*, *Jenna*?), so having multiple name options that sound like the target's first name becomes more problematic with age. In contrast, phonologically-related nouns typically are not viable candidates and thus do not interfere (e.g., *bunny* and *bus* possess unique semantic properties that make them inappropriate choices when attempt to produce *butter*).

A new direction for future research is the role of semantic priming on older adults' TOT resolution. Whereas there is little evidence of semantic priming effects on TOT incidence, as discussed earlier, there is some evidence from young adults that semantic relatedness can reduce the facilitative effect of phonological priming on TOT resolution for names. White, Abrams, and

Frame (2013) examined the effect of semantic relatedness between primes and targets on phonological priming of younger adults' TOT resolution for famous names. They presented questions whose answers were proper names, and TOT responses were followed by another question that contained either a prime name or an unrelated name. Primes were either semantically related (in the same occupation as the target) or unrelated. Primes were also phonologically related by sharing either the target's first name or the first syllable of the first name. The TOT question was presented again, and TOT resolution occurred if the target name could now be retrieved. The results showed that when a prime shared the first name with a target, it facilitated TOT resolution regardless of whether it was semantically related or unrelated. In contrast, when the prime contained some but not entire phonological overlap with the target's first name (first syllable only), semantically-unrelated primes increased TOT resolution, but semantically-related primes did not.

Although White et al. (2013) did not compare names with nouns, there are relatively few nouns that share both semantic and phonological characteristics. If names are more likely than nouns to have semantic overlap along with partial phonological overlap, conditions that impede TOT resolution, then this could contribute to names being more difficult to retrieve than nouns in everyday life. Additionally, the finding that semantic relatedness between primes and targets can interfere with phonological priming of TOT resolution could have interesting implications for older adults. For example, one possibility is that the oldest adults would experience inhibitory effects on TOT resolution from shared semantic category, phonological primes, similar to that observed from grammatical class (Abrams et al., 2007), resulting in a reduction in TOT resolution relative to unrelated names. Older adults are thought to have enriched semantic networks (e.g., Laver & Burke, 1993; Light & Burke, 1993; Taylor & Burke, 2002), which could

potentially make them more susceptible to competition from semantically-related prime names that also share first syllable.

Lastly, the effects of non-cognitive influences on TOTs, such as stress or emotion, and their interactions with aging are virtually unexplored. A link between stress and TOTs has been informally suggested via anecdotal evidence (Cohen & Faulkner, 1986; see also Brown, 1991, and Schwartz, 2002), where TOTs are thought to be more likely to occur when a person is under stress. James, Schmank, and Castro (2013) have empirically demonstrated this relationship in college student participants by putting them in a high- or low-stress situation involving preparation of a speech, a modified Trier Social Stress Test. In the high-stress condition, participants prepared a five-minute speech regarding a job interview and then gave the speech with the belief that they were being analyzed by an expert watching them through a one-way mirror. In the low-stress condition, participants also prepared and gave a speech, but the topic was a favorite vacation spot, and they gave the speech without an observer. After a brief intervening period of mental arithmetic, participants were given the TOT questions and attempted to retrieve the answers. The results showed that participants experienced more TOTs in the high-stress condition than in the low-stress condition, suggesting that situational stress in close proximity to word retrieval is detrimental. An interesting question is whether older adults, who may be generally more anxious about having memory failures (e.g., Cohen & Faulkner, 1986; Pearman & Storandt, 2004; Ryan, Kwong See, Meneer, & Trovato, 1992), are particularly susceptible to the effects of stress on TOTs.

A few studies have examined the effect of emotion on TOTs in young adults, where emotion was elicited through the general knowledge questions presented to elicit TOTs (d'Angelo & Humphreys, 2012; Schwartz, 2010). Specifically, emotion was defined in terms of

"uncomfortable questions, related to topics likely to be considered negative", such as "What is the term for ritual suicide in Japan?" (answer: *seppuku*). Schwartz (2010) compared emotion-inducing questions with neutral questions in terms of their likelihood of inducing TOTs, and he reported that more TOTs occurred for emotion-inducing questions than for neutral questions. He also reported a carryover effect such that higher TOT rates also occurred on the next question following an emotion-inducing question. However, these results were challenged by d'Angelo and Humphreys (2012). They determined that in the Schwartz (2010) experiment, the targets corresponding to emotion-inducing questions were lower in word frequency and had fewer phonological neighbors than targets corresponding to neutral questions, variables that increase TOTs (Burke et al., 1991; Harley & Bown, 1998). After controlling for these differences, d'Angelo and Humphrey failed to replicate Schwartz's findings of an effect of emotion on TOTs, so the link between emotion and TOTs remains unclear.

It is also worth noting that emotion defined by the to-be-retrieved word is quite different from the emotion inherently experienced within the person, the latter of which can be observed in older adults' self-reports of TOTs as their most annoying cognitive failure (Lovelace & Twohig, 1990). However, older adults may be better able to manage the emotional arousal that seems to accompany their TOTs. Research has been converging on the idea that older adults have superior emotion-regulation skills (e.g., Carstensen, Isaacowitz, & Charles, 1999; Mather & Knight, 2005) relative to younger adults, evidenced by older adults having greater confidence in their ability to manage their emotions (e.g., Gross et al., 1997; Kessler & Staudinger, 2009; Lawton, Kleban, Rajagopal, & Dean, 1992), and lower levels of physiological arousal in response to some emotional situations (e.g., Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Levenson, Carstensen, Friesen, & Ekman, 1991; Tsai, Levenson, & Carstensen, 2000).

Furthermore, older adults attend to and remember proportionally more positive information than negative information (the positivity effect; e.g., Charles, Mather, & Carstensen, 2003; Grühn, Scheibe, & Baltes, 2007; see also Scheibe & Carstensen, 2010, for a review), an effect thought to stem from an enhanced ability to inhibit negative information (Mather & Knight, 2005). Thus, it remains to be seen whether older adults' enhanced emotion regulation skills can offset the effect of emotional state or arousal on a task involving speech production.

Conclusion

The awareness that TOTs increase with age is only a starting point for understanding the complex issues that underlie why this phenomenon occurs. While this change is a normal part of the healthy aging process and can be differentiated from retrieval problems that accompany neurodegenerative diseases, it nonetheless remains a frustrating and potentially socially-isolating annoyance of which older adults are consciously aware. As this chapter demonstrates, language production processes are subject to a variety of influences, many of which capitalize on normal age-related decline to disproportionately increase TOT incidence and reduce TOT resolution for older adults. It has yet to be determined whether it is more fruitful for researchers to focus on ways of mitigating older adults' TOTs in the first place or to hone in on strategies that increase their resolution of TOTs. However, it is clear that the first step is developing a comprehensive, theoretical understanding of these retrieval failures and the factors that account for increased susceptibility during the aging process.

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Author Notes

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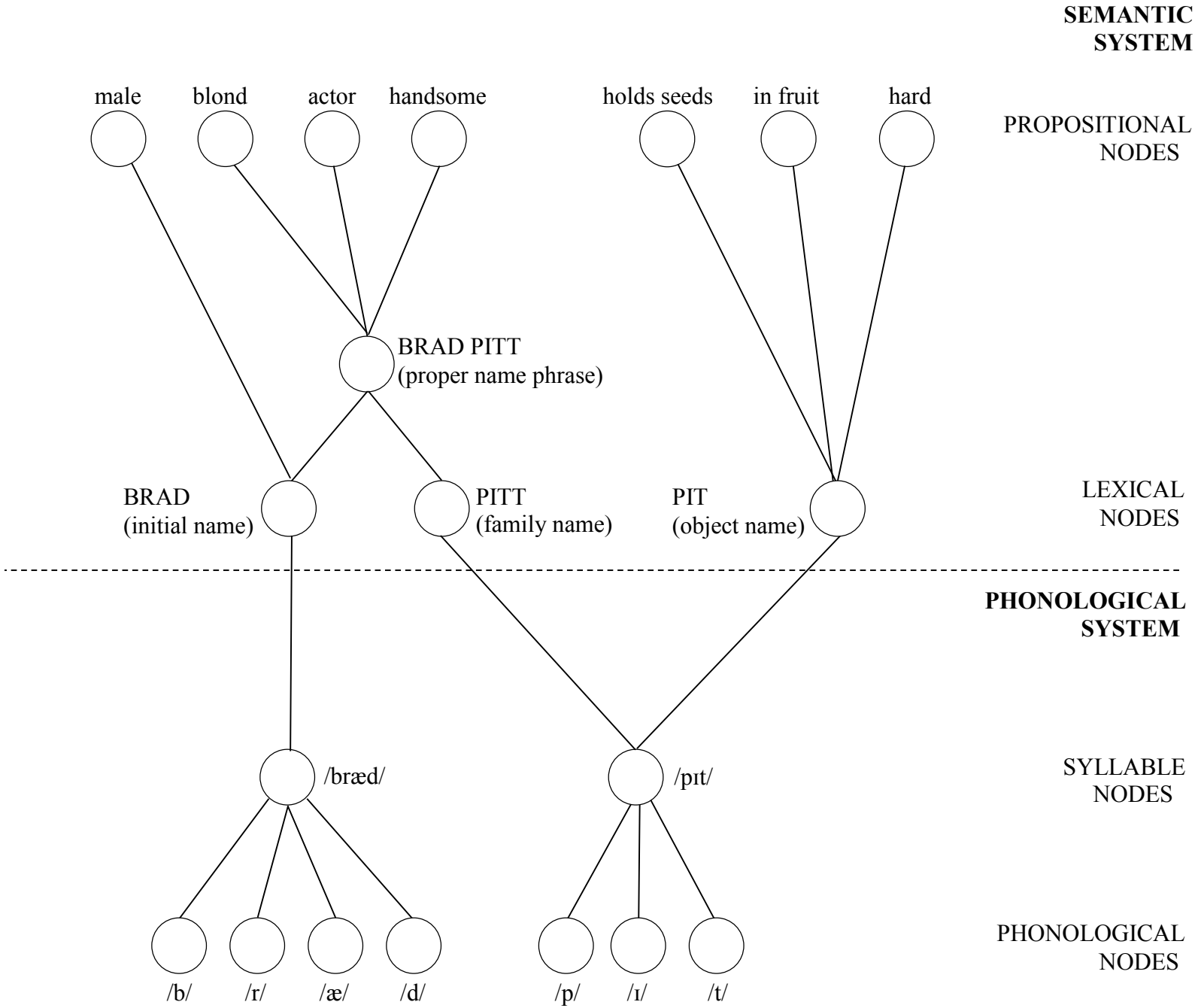

Figure 1. Representation of proper names and non-names according to TDH (adapted from Burke, Locantore, Austin, & Chae, 2004).

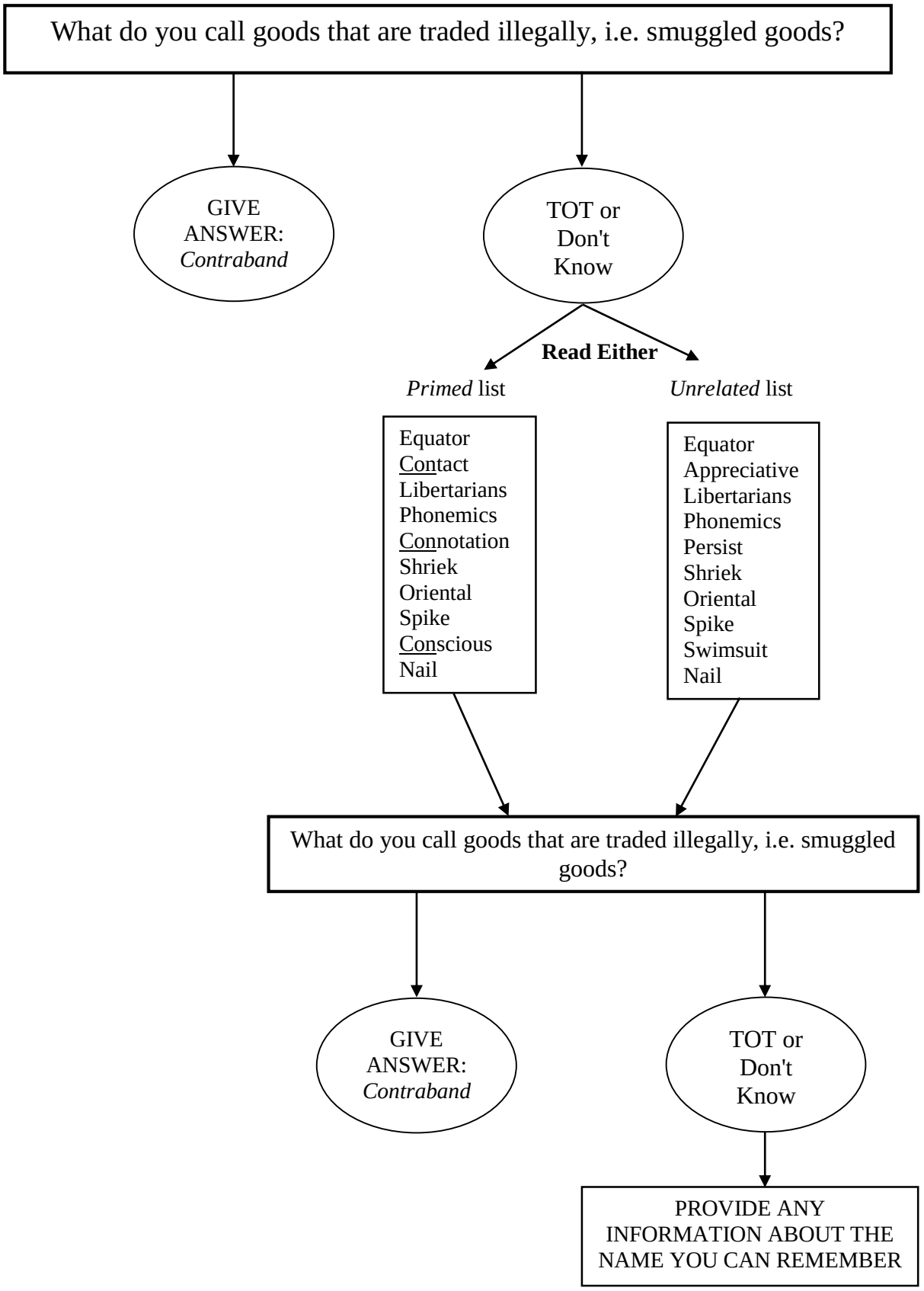

Figure 2. Example TOT priming resolution methodology (adapted from Abrams, White, & Eitel, 2003). The first syllable in the primed list is underlined for emphasis here.