REPEATED TIP-OF-THE-TONGUE STATES

REPEATED TIP-OF-THE-TONGUE STATES: A CLOSER LOOK AT THE ERROR REPETITION EFFECT

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy

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**Lay Abstract**

 A tip-of-the-tongue (TOT) state is the feeling of knowing a word, but being unable to produce the sounds to articulate the word. A TOT state is often accompanied by a feeling of frustration. For example, a TOT state may occur when one encounters a colleague at work. One may remember the first letter of the colleague’s name, and the name may feel like it is figuratively within reach, but the full name cannot escape the speaker’s lips. Perhaps even more frustrating is the occurrence of a TOT state time after time for a specific word. This dissertation explores the tendency for TOT states to recur. The results point towards the hypothesis that repeated TOT states are the result of a specific breakdown in the portion of the word production system that connects syntactic units to phonological units.

**Abstract**

 There are some disagreements surrounding what constitutes a tip-of-the-tongue (TOT) state. The most widely accepted hypothesis to account for TOT states is the Transmission Deficit Hypothesis, which suggests TOT states are the result of a phonological access failure (Burke, Mackay, Worthley, & Wade, 1991). The TOT state is largely hypothesized to be a general subthreshold state, which suggests that the TOT state does not have a specific underlying mechanism. A relatively new line of inquiry involves that of repeated TOT states. As a theoretical extension to the phonological failure account of TOT states, Warriner and Humphreys (2008) found that TOT states repeat at a rate greater than would be predicted by chance, which has been termed the *error repetition effect*. They argue that the mechanism underlying the error repetition effect is a Hebbian-like error learning mechanism, suggesting that the TOT state is not a general state, but rather a specific state. D’Angelo & Humphreys (2015) did an extensive study that provided evidence for the validity of the error repetition effect. This dissertation explores additional features of the TOT state that had not been previously tested. The first study explored what is being learned during a TOT state. Specific phonological information was found to repeat along with repeated TOT states, supporting the phonological failure hypothesis. Second, this dissertation includes the first study to determine if older adults experience the error repetition effect using Warriner and Humphreys’ (2008) methodology. The evidence suggests that repeated TOT states are a part of normal aging rather than pathological cognitive dysfunction. Third, metacognition researchers argue that the TOT state is a subjective experience caused by a mechanism that assesses the likelihood of recall from memory. The third study demonstrates evidence contrary to the metacognitive account, which further supports the phonological failure account of TOT states.

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Chapter three of this dissertation is dedicated to Mary “Nanny” (MacDougall) Oliver.

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**Declaration of Academic Achievement**

 This dissertation contains three studies that aim to further the field of word production. The first chapter summarizes key aspects of the relevant literature and issues that will be addressed in this dissertation. I will be the first author on all three studies, which have all been submitted for publication. All three studies have been in collaboration with my supervisor, Dr. Karin R. Humphreys.

 Chapter two involves a repeated tip-of-the-tongue task (one week between test and retest) in which participants (young adults) are encouraged to speak aloud. This task was conceptualized in collaboration with Dr. Karin Humphreys. Dr. Scott Watter programmed the task. Esther Manoian and I collected the data. Various undergraduate research assistants assisted with utterance transcription. I developed the coding scheme and coded the responses. I wrote the introduction, methods, and results. Both Dr. Karin Humphreys and I wrote the discussion.

 Chapter three involves a repeated tip-of-the-tongue task (5 minutes between test and retest) for older adults. This task was conceptualized in collaboration with Dr. Karin Humphreys. I designed the study and chose the stimuli for the task. Esther Manoian, various undergraduate students (whom I trained and supervised), and I collected the data. I analyzed the data. I wrote the introduction, methods, results, and discussion for the paper.

 Chapter four involved the amalgamation of two honours theses belonging to Jonathan Harley and Timmie Li, plus an additional experiment. I was involved in combining and theoretically restructuring the two studies to create an amended study that refutes the hypothesis that TOT states are the result of a metacognitive phenomenon. I wrote the introduction and discussion, and restructured the remaining subsections of the paper.

All of my committee members have provided edits and feedback on all three studies within this dissertation.

**Chapter 1 – A General Introduction to Tip-of-the-Tongue States**

**Speech Errors**

 An efficient word production system underlies human speech, demonstrated by an average speech rate of two to three words per second (Levelt, 1989; Levelt, 2001). However, the system underlying word production is not unflawed. Speakers tend to make a speech error 1-2 times per 1,000 words (Levelt, 1989; Levelt, 2001). The study of speech errors has offered influential findings and theoretical models of spoken language production (e.g., Dell, 1986; Fromkin, 1973; Garrett, 1975; Levelt, Roelofs, & Meyer, 1999). For instance, speech errors have been found to occur in a meaningful and systematic way (e.g., Dell, 1986). Word production failure presents the opportunity to observe a slowed-down, step-by-step retrieval process. Of course, it is not possible to directly observe a tangible word production system. Psycholinguists must primarily rely on behavioural data. Typically, researchers experimentally elicit speech errors, and then analyze the data to determine if there are statistical patterns present within the utterances (e.g., Humphreys, Menzies, & Lake, 2010). When thinking about speech errors, one may immediately think of malapropisms or spoonerisms (i.e., slips-of-the-tongue). This dissertation addresses a different type of speech error, which is the tip-of-the-tongue (TOT) state.

**Tip-of-the-Tongue States**

 A TOT state is the feeling of knowing a word, but being unable to produce the necessary sounds to articulate the word. In a sense, it is unfitting to think of a TOT state as a speech error, given that the correct information is present within the lexicon, but is merely inaccessible (see Burke, Mckay, Worthley, & Wade, 1991 for an accessibility account of TOT states). Rather the TOT state is labeled as an erroneous state as it is by and large a word production system failure. Even though the correct units are partially activated, the lack of activation required to reach threshold leads to inarticulation of the target word (Burke et al., 1991). In a sense, this paradoxical description of the TOT state is what makes it an enigmatic occurrence. Theoretically, unlike slips-of-the-tongue, TOT states give psycholinguists the opportunity to observe word production when a target word is going through the correct stages of production, but is stalled at the phonological level.

 TOT states were first described by William James (1890), but the first empirical study on TOT states was not undertaken until 1966 by Brown and McNeill, who found that speakers could report the phonological properties of a word during a TOT state at a rate greater than could be predicted by chance. Ever since this pivotal study, there has been much debate surrounding the nature of TOT states (i.e., what constitutes a TOT state). While metacognitive researchers view the TOT state as a subjective experience caused by a mechanism that assesses the likelihood of recall from memory (e.g., Schwartz & Metcalfe, 2011), this dissertation is based on the psycholinguistic view (i.e., temporary phonological inaccessibility) (Burke et al., 1991). Among psycholinguistics, it is widely accepted that word retrieval occurs in two stages—semantic access followed by phonological access (e.g., Burke et al. 1991; Dell, 1986; Dell, Schwartz, Marin, Saffran, & Gagnon, 1997; Levelt et al., 1999; Roelofs, 1997). When the most strongly activated conceptual information is chosen, the non-linguistic information is mapped onto the grammatical and syntactic units for the target word, which is known as the lemma level. The grammatical and syntactic units are then mapped onto the phonology of the word, and from there successful articulation can occur. The phonological accessibility view is based on the argument that TOT states are a product of a failure in phonological access rather than a general memory failure for lexical information. According to this view, a TOT state occurs when there is successful conceptual-to-lemma access, but failed lemma-to-phonological access, which is often referred to as the Transmission Deficit Hypothesis (TDH; Burke et al., 1991). Primary evidence for the TDH comes from the finding that speakers can often retrieve phonological features related to the target word (e.g., Brown & McNeill, 1966), and also cueing effects, where participants are able to resolve a TOT after being given a phonological cue, but not a semantic cue (Brennen, Baguley, Bright & Bruce, 1990; D’Angelo & Humphreys, 2015; Meyer & Bock, 1992).

**Repeated Tip-of-the-Tongue States**

 After the emergence of the TDH, Warriner and Humphreys (2008) brought forth the argument that the TOT state may be even more mechanistically specialized than outlined in the TDH literature by Burke and colleagues. Until recently, The TOT state was largely hypothesized to be a general subthreshold state, meaning that the activation of phonological units does not reach the threshold required to become activated. From this perspective, the TOT state does not have a specific underlying mechanism; a TOT state occurs when nodes are weakened due to recency or frequency effects, for example (Burke et al., 1991). However, it has been found that TOT states for a specific word repeat at a rate greater than expected by chance, which has been labeled the *error repetition effect* (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Humphreys and colleagues interpret the error repetition effect as an *error learning effect*; that is, speakers may learn the incorrect lemma-to-phonology mappings during the word retrieval process. The error repetition effect occurs at immediate retest, a 48-hour delay, and a one-week delay, and occurs despite verifying the correct target at the end of each trial during an initial test. As mentioned, the TOT state is argued to occur between the lemma and phonological units within the word production system. Given that speakers can often think of phonological properties of the target word, Humphreys and colleagues argue that speakers actually learn this partially activated phonological pathway. They argue that this error repetition effect (i.e., the tendency for TOT states to repeat) occurs through a Hebbian-type learning mechanism, which strengthens the incorrect (i.e., partial) lemma-to-phonology mapping. From the error repetition standpoint, Warriner and Humphreys (2008) have added a novel theoretical perspective to the field of word production, which is that TOT states are not necessarily the result of a general sub-threshold state, but rather a specific local minimum where activation converges on a partial, but ultimately incorrect phonological pattern. Consequently, the speaker gets stuck on an error-learning pattern, which leads to a TOT state every time that specific target word is encountered.

 The error learning interpretation of the error repetition effect has met criticism, with the main critique being whether the tendency for TOT states to repeat is simply due to idiosyncratic difficulty for a particular word. The current evidence does not point toward the idiosyncratic account of repeated TOT states, but rather toward an error learning account. For instance, Humphreys and colleagues have found that the amount of error repetition observed can be manipulated by varying the interval of time randomly given to think about a particular target word aloud during a TOT state. Warriner and Humphreys (2008) found that those who were given more time to think about the answer (30s) had a greater tendency to repeat their TOT states than those who were only given a short interval of time (10s) to think about the answer. In other words, they did not try to manipulate the likelihood of entering a TOT state on the first test, but rather they manipulated the amount of potential learning that could occur after the participant entered a TOT on the first test. It is the amount of learning that occurred during the interval of time to think about the target word aloud on the first test that determined whether or not a TOT response occurred on retest. D’Angelo and Humphreys (2015) were initially inconsistent in their ability to replicate the timing manipulation effect, but they found that the effect was dependent on whether or not the experimenter was actively encouraging the participant to speak aloud about the target word during a TOT state. Active encouragement to speak aloud may drive participants to think harder about the target word, leading to strengthening of the erroneous lemma-to-phonology pathway, and therefore increasing error learning. TOT states are also less likely to repeat for a particular word on retest if the TOT state was self resolved on the first test. This is referred to as the *resolution effect*. Humphreys and colleagues argue that although erroneous lemma-to-phonology mappings can be learned, these erroneous connections can also be unlearned. If a speaker conducts a successful search for the target word during a TOT state, the TOT state may be unlearned by creating a new and correct pathway to the target word, and thereby weakening the old and incorrect one. In line with the resolution effect, D’Angelo and Humphreys (2015) found a cued resolution effect, meaning that those who are given the first few letters of the target word during a TOT state were less likely to repeat that TOT state on retest. The cue serves as an aid in self-corrective learning so that one is less likely to access the incorrect pattern of phonology in the future. Given that the statistical tendency for TOT states to repeat (i.e., the error repetition effect) is a relatively new finding in the field, and also one that is often overshadowed by the original Transmission Deficit Hypothesis (Burke et al., 1991), there is much work to be done on the tendency for TOT states to repeat.

**Current Studies**

 Within this dissertation there are three novel studies that build upon Warriner and Humphrey’s (2008) findings that TOT states tend to repeat in a systematic manner. That is, specifically, TOT states repeat at a rate greater than predicted by chance if a TOT state is left unresolved (i.e., the speaker could not articulate the correct answer). These chapters attempt to uncover some of the lingering questions that surround repeated TOT states. The general research design is consistent across the studies outlined in this dissertation– TOT states are experimentally elicited on Test 1 by asking participants to think of the word or name that goes with a particular stimulus, followed by a delay period, and then a retest. D’Angelo and Humphreys (2015) performed an extensive set of studies to confirm that the error repetition effect is a real and replicable effect, thus offering support for the error learning account of the error repetition effect. Further validation of the error learning account of the error repetition effect is not the primary goal of this dissertation. Rather, the goal is to bolster Humphrey and colleagues’ previous findings by exploring various properties of repeated TOT states. Specifically, this dissertation examines the roles of interlopers, advanced age, dementia, and metacognitive properties (or rather, a lack thereof) of repeated TOT states. On the whole, the results outlined in this dissertation do point towards an error learning account of the error repetition effect.

 Chapter two (Study 1) examines the role of interlopers in repeated TOT states. Considering that Warriner and Humphreys (2008) argue that repeated TOT states are the result of an error learning mechanism, then what exactly is being learned? Study 1 unravels this question by investigating the types of information that speakers are thinking of during a TOT state. A notable feature of TOT states is that speakers can often recall features of words that are on the tip-of-the-tongue (e.g., Brown, 1991; Brown, Burrows, Caderao, & Croft, 2013; Brown & McNeill, 1966; Meyer & Bock, 1992; Schwartz & Metcalfe, 2011). These are sometimes referred to as interlopers. These interlopers can be entire words – for example only being able to recall the word “oblong” when trying to recall “obsidian”, or there might be partial phonological information, such as the onset phoneme, or the number of syllables. Related semantic information may also come to mind. However, recall that TOT states are hypothesized to occur between the lemma and phonological level of the word production system. If a speaker can only think of semantically related information to the target word, then it is unlikely that the speaker is in a real TOT state. When TOTs recur, do corresponding interlopers recur as well? Furthermore, what kinds of interlopers are associated with recurring TOTs? The results are consistent with Warriner and Humphreys’ (2008) findings and arguments, in that not only were unresolved TOT states most likely to repeat, but during repeated unresolved TOT states (but not resolved or Don’t Know states), specific phonological information was likely to repeat at a rate greater than predicted by chance. Theoretically, these results are highly informative regarding the nature of the TOT state itself. Specifically, the tendency for phonological interlopers to repeat sheds light on what the pattern of activation may look like during the process of erroneous learning. The results suggest an organized pattern of activation whereby the system has converged on a partial, but ultimately incorrect pattern, and remains trapped in this erroneous state.

 Chapter three (Study 2) examines the error repetition effect in older adults, mainly whether the error repetition effect occurs in older adults at all. Study 2 also examines the associations between repeated TOT states, age, and cognitive functioning. To date, this is the only study to examine the error repetition effect in older adults using Warriner and Humphreys’ (2008) methodology. Older adults were chosen as a secondary population of interest due to some interesting properties of their cognitive functioning. Excluding older adults with dementia, healthy older adults are at a stage where the brain can be perfectly healthy, but there is some cognitive slowing. This slowing possibly makes older adults more vulnerable to experiencing repeated TOT states. Unsurprisingly, TOT states occur more frequently in older adults (e.g., Brown & Nix, 1996; Burke, MacKay, Worthley &, Wade, 1991; Dahlgren, 1998; Farrell & Abrams, 2011; Heine, Ober, & Shenaut, 1999; Juncos-Rabadan, Facal, Rodriguez & Pereriro, 2010; Rastle & Burke, 1996; Salthouse & Mandell, 2013). Anecdotally, it is not uncommon for an elderly person to express concerns regarding dementia and their ever-increasing word finding problems. Yet, the study outlined in Chapter Two is the second study ever to examine repeated TOT states in older adults. Middleton and Schwartz (2013) has been the only other study to investigate the error repetition effect in older adults. They explored error repetition in older adults with and without aphasia. However, there is a fundamental difference in the way the results were analyzed between Middleton and Schwartz (2013) and Study 2 in this dissertation, which obscures the presence of error repetition. Specifically, Middleton and Schwartz (2013) analyzed differences in the proportion of repeated TOT states between the short and long conditions (more error learning should be present in the long condition). Arguably, proportions do not capture how an individual experiences a repeated TOT state. Specifically, Humphreys and colleagues hypothesize that a Test 2 TOT state is dependent on the Test 1 response, which is not possible to discern from analyzing the general difference in number of repeated TOT states between conditions. Therefore, TOT repetition should be defined as the recurrence of an individual TOT state at a rate greater than can be predicted by chance.

 Study 2 is the first study to examine repeated TOT states in a group of both healthy and cognitively impaired older adults. In order to solidify the error repetition effect as a real effect, it must occur in other populations. An error repetition effect was found in older adults. While we did not directly address whether or not the error repetition effect is due to an error learning mechanism as argued by Warriner and Humphreys (2008), we were able to uncover a fascinating feature of repeated TOT states in older adults; that is, repeated TOT states are positively associated with age, but are not associated with cognitive dysfunction as measured by the MoCA. While this study is correlational rather than experimental, it is nonetheless an important first step toward uncovering the relation between TOT states and cognitive functioning. Other studies have found that there is no association between TOT states (i.e., experimentally eliciting a TOT state only one time – there is no retest) and memory decline (Salthouse and Mandell, 2013), which further corroborates our finding.

 Chapter four (study 3) uses the error repetition effect to contrast the metacognitive versus psycholinguistic (i.e., phonological failure) account of the TOT state. Psycholinguists hypothesize that the TOT state serves as a phenomenon that provides direct observation as to how lexical selection occurs (e.g., Burke, MacKay, Worthley, & Wade, 1991; Gollan & Brown; 2006; Harley & Bown, 1998; Meyer & Bock, 1992; Vitevitch, 2002; Warriner & Humphreys, 2008). Metacognition researchers view the TOT state as the subjective feeling of temporary inaccessibility, placing focus on the dissociation between the subjective experience of a TOT state and word retrieval processes that occur in the speech production system (e.g., Schwartz, 2001). Specifically, our goal was to determine if the cue familiarity hypothesis could account for the error repetition effect. The cue familiarity hypothesis suggests that a TOT state may be caused by cues that trigger a feeling of familiarity (as described in Schwartz, 2001). If a cue is highly familiar, a TOT state should be more likely. Definitions with repetitive information are more likely to induce a TOT state than a short and concise definition (Koriat & Lieblich, 1977; Schwartz, 2001). It is argued that this accretion of cues can lead to a TOT state. In accordance with this view, the TOT state is more dependent on the cue than it is on the inaccessible target word.

 In the context of repeated TOT states, Study 3 includes three experiments to examine the cue familiarity hypothesis using the error repetition effect. In the repeated TOT paradigm by Humphreys and colleagues, identical definitions are used on test and retest. From a metacognitive standpoint, the definition used to elicit a TOT state on the first test functions as a cue on retest. Due to the definition having already been presented on Test 1, the familiarity of the cue on Test 2 may be driving the participant to report a TOT state, leading to the illusion of learned TOT states. In the first experiment, the Warriner and Humphreys (2008) paradigm was used, where definitions of words are presented to participants at the first test, but with the change that either an identical or an alternative definition of the same word is used at retest. We note that an alternative definition may not differ enough from the original definition to be a significantly different memory cue, so we addressed this problem in Experiment 2. Participants were presented with very different (i.e., alternative) memory cues (faces and descriptions of actors, with the goal of retrieving their names). If there is no difference in the likelihood of a repeated TOT on Test 2, we argue that this is further evidence to support the failed phonological selection account rather than the cue familiarity hypothesis. It was found that whether participants were given the same definitions or different definitions on test and retest, the nature of the error repetition effect remained the same, discounting the metacognitive account of the TOT state. The third experiment was an even more direct test of whether or not the semantic level of word production is directly implicated in TOT states. Rather than directly test the lemma-phonological component of TOT states, we decided to instead examine the role of semantics in TOT state etiology considering that semantics are not often the primary point of interest in psycholinguistic studies that examine TOT states. Providing extra semantic information did not induce a higher likelihood of repeated TOT states. This finding provides evidence that the semantic-to-lemma connections are not the locus of repeated TOT states.

 In summary, this dissertation takes a closer look at the tendency for TOT states to repeat by examining a multitude of factors (i.e., interlopers, age, dementia, cue familiarity) that have not been previously tested in the context of the error repetition effect. These studies were designed to further the field of psycholinguistics by providing insight on various underlying components of the word production system.

**Chapter Two – Phonological Interlopers Tend to Repeat When Tip-of-the-Tongue States Repeat**

Oliver, L.K. & Humphreys, K.R. (in review). Phonological interlopers tend to repeat when tip-of-the-tongue states repeat. *Frontiers in Psychology.*

 A tip-of-the-tongue (TOT) state is the feeling of knowing that one knows a word, yet being unable to say it (Brown & McNeill, 1966). The experience of being in a TOT state is typically frustrating, followed by a feeling of relief if the correct word is attained (Brown, 1991). The TOT state is a unique, universal state that plagues every speaker at least some of the time. The TOT phenomenon is of particular interest to psycholinguists. TOT states are hypothesized to be a direct consequence of a word production failure, which has led to significant and influential findings in the field of word production (e.g., Burke, Mackay, Worthley, & Wade, 1991). Burke and colleagues argue that TOT states are the direct consequence of a phonological failure (mechanism explained below). It can be especially frustrating when a TOT state seems to happen repeatedly for the same word, which is a relatively underexplored feature of TOT states; that is, TOT states tend to repeat (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Humphreys and colleagues argue that TOT states recur due to an error learning mechanism within the word production system. The current paper attempts to replicate the finding that TOT states tend to repeat, but we also explored an additional line of inquiry. Specifically, what is being learned during a TOT state?

**TOT States and the Two-Stage Model of Word Retrieval**

 The most widely agreed-upon model of language production is a two-stage model, where activation proceeds from a concept—the non-linguistic stage—to the lemma, and the lemma to phonology (Badecker, Miozzo, & Zanuttini, 1995; Dell, 1986; Dell, Schwartz, Martin, & Saffran, 1997; Levelt, Roelofs, & Meyer, 1999). The lemma is defined as an abstract pointer to the target word in that it is a lexical unit that holds syntactic information, but is not yet connected to sound. The lemma is then mapped onto phonemes, which creates the sound of the word. Within this framework, a TOT state is thought to represent some kind of failure of activation in this mapping process, and is specifically hypothesized to reflect a successful retrieval of a lemma, but an unsuccessful subsequent activation of the full phonological representation of that word (Burke, Mackay, Worthley, & Wade, 1991; D’Angelo & Humphreys, 2015; Dell, 1986; Dell et al., 1997; Gollan & Brown, 2006; Levelt, Roelofs, & Meyer, 1991; Warriner & Humphreys, 2008). A TOT state may occur the first time when phonological failure occurs due to noise in a spreading-activation-like system, which is heightened by relatively weak connections within the word production system (e.g., Dell, 1986; Dell et al., 1997). For example, if a word has not been used for a long period of time or if a word is used on rare occasions, lemma-to-phonology connections may become weakened due to disuse, leading to a TOT state (e.g., Burke et al., 1991).

**Repeated TOT States**

 Providing some theoretical extensions and modifications to Burke and colleagues’ work, Humphreys and colleagues have shown that TOT states tend to repeat for individual words (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). That is, speakers who experience a tip-of-the-tongue state on a word are more likely to TOT on the same word again than would be predicted by chance; this phenomenon is called the *error repetition effect*. Although a robust error repetition effect has been found, there is uncertainty surrounding the factors that may contribute to this effect. Humphreys and colleagues have argued that this error repetition effect is not simply due to the fact that some words tend to be idiosyncratically difficult for speakers (due to low frequency, low neighbourhood density, etc.). Instead, they argue that speakers are learning the error itself (see D’Angelo & Humphreys (2015) and Warriner & Humphreys (2008) for a much more extensive argument on the error learning effect). This can be described as the language production system learning from experience in that it is constantly being updated with every word spoken (Oppenheim, Dell, & Schwartz, 2010; Warriner & Humphreys, 2008). Theoretically, the TOT state may consist of an incorrect mapping between lemma and phonology, and that incorrect pathway is reinforced via a Hebbian-type learning mechanism, thus making the error more likely in a subsequent retrieval attempt (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008).

 This paper does not directly address whether or not the error repetition effect is due to learning, but rather we attempted to build upon D’Angelo and Humphreys (2015) and Warriner and Humphreys (2008) findings that do provide extensive experimental support for an error learning mechanism underlying at least a portion of the error repetition effect. Evidence for an error learning effect comes from a timing manipulation technique used by Warriner and Humphreys (2008), which serves as a way to manipulate the amount of error learning that occurs. Those who were given more time to actively search for the target word during a TOT state were more likely to repeat a TOT state on retest, even after being shown the correct answer. Furthermore, D’Angelo and Humphreys (2015) found a cued resolution effect, meaning that those who are given the first few letters of the target word during a TOT state were less likely to repeat that TOT state on retest. The cue serves as an aid in self-corrective learning so that one is less likely to access the incorrect pattern of phonology in the future.

**Interlopers**

 A notable feature of TOT states is that speakers can often recall features of words that are on the tip-of-the-tongue (e.g., Brown, 1991; Brown, Burrows, Caderao, & Croft, 2013; Brown & McNeill, 1966; Meyer & Bock, 1992; Schwartz & Metcalfe, 2011). These are sometimes referred to as interlopers. These interlopers can be entire words – for example only being able to recall the word “oblong” when trying to recall “obsidian”, or there might be partial phonological information, such as the onset phoneme, or the number of syllables. Related semantic information may also come to mind. This paper looks at interlopers in the context of the error repetition effect in TOT states. When TOTs recur, do corresponding interlopers recur as well? Furthermore, what kinds of interlopers are associated with recurring TOTs? Critically, this information can inform us about the nature of the TOT state itself.

 Experimental paradigms that have been used to explore interlopers typically involve the presentation of a potential interloper at the beginning of a trial, before TOT elicitation (e.g., Maylor, 1990). Interlopers have also been studied through participants self-recording their TOTs and what words come to mind throughout a period of time (e.g., Burke et al., 1991), but thus far there has been no study of experimentally elicited TOT states and naturally occurring interlopers across multiple testing sessions. Interlopers are often presented before TOT elicitation, and although this provides insight as to what happens before a TOT state occurs, by examining naturally occurring interlopers in a controlled setting we can examine what is happening during the TOT state.

**Theoretical Account of TOT States as a Specific State**

 While Humphreys and colleagues have argued that repeated TOTs represent an error learning effect, the question remains: what is being learned? Previously, it was argued that it might represent some kind of Hebbian learning mechanism, strengthening the connection between the lemma and an incorrect phonological representation, which makes speakers less likely to be able to use the correct mapping on a subsequent retrieval attempt. This bears directly on the question of what the pattern of activation during a TOT state is like. We make the assumption that the lemma has been correctly retrieved, and the TOT state is a function of failure to retrieve a fully correct phonological pattern. The first possibility is that there is a general subthreshold state in which no phonological pattern reaches threshold for selection, although there might be partial or related information retrievable (e.g., Burke et al. 1991). The other possibility is a blocking hypothesis (e.g., Jones, 1989), in which the phonological pattern corresponding to an incorrect word is selected and this prevents the selection of the correct pattern.

 Within the idea of the general subthreshold state, however, it is not clear what that state would look like. The frequent ability of speakers to identify partial phonological information, or report sound-alike interloper words certainly suggests a fairly organized pattern of phonological activation that is consciously accessible. We acknowledge that there are cases when participants do not identify partial phonological information. These alternative cases may occur for multiple reasons. First, some participants may be reluctant to report information about the target word for fear of being wrong. Other participants may have certain traits that inhibit them from speaking aloud (e.g., shyness). In other cases, we speculate that there is enough random noise within the word production system that the noise makes it difficult for a speaker to pinpoint specific phonological information to report. However, we acknowledge that this is a statistical tendency and not a systematic one, and at this stage of the development of the error repetition hypothesis, this explanation is more so speculative than it is definitive, but is nonetheless a plausible and promising hypothesis.

 One possible analogy is that of a local minimum in an autoassociative type network, in which the system has converged on a partial, but ultimately incorrect pattern, and remains trapped in this erroneous state. Alternatively, the subthreshold state might not be associated with a convergence at a local minimum, but remains a state in which simply nothing is activated highly enough to be selected. It is certainly possible that individual TOT instances may sometimes be more like one of these alternatives than the other – i.e., in cases where partial report of an interloper is available, this might represent convergence at a local minimum. In cases where no phonological information is available, there might simply not be enough activation available to form any kind of coherent pattern of activation.

 In thinking about possible mechanisms that underlie a learning effect in TOTs, understanding the nature of the underlying state is critical. If in fact TOTs often represent something akin to an erroneous convergence on a local minimum, then the error learning effect can be fairly straightforwardly described as the strengthening of the connection between lemma and that specific erroneous state of phonological activation. In this explanation, that new reinforced mapping is then at an increased likelihood of being used again on a subsequent retrieval, and leading to another TOT. This explanation then makes the prediction that repeated TOTs are likely to have similarly repeated erroneous phonological information available. That is, not only is the failure to retrieve a word repeated, but the specific error state is repeated as well.

**Current Study**

 This study was designed to investigate error learning in TOT states by exploring the role of interlopers. Data were analyzed to determine if errors repeat, and if interlopers repeat along with them. It was hypothesized that the likelihood of being in a TOT state for a particular word on Day Two will be greater given that a participant was in a TOT state for the same word on Day One, especially for TOTs that were not resolved on the first day, replicating earlier findings. The think-aloud protocols were analyzed to determine whether participants were reporting interlopers, what kind of interlopers they were (e.g., semantic or phonological) and to what extent those interlopers repeated at the subsequent retrieval attempt. If specific interloper information repeats, this is evidence for a TOT state as being a relatively specific erroneous pattern of activation that can be learned, and can reoccur, rather than a non-specific subthreshold activation state. Showing that a specific state of activation occurs during the TOT provides further evidence for a mechanism by which TOT error learning can occur.

**Methods**

**Participants**

Participants included 40 native English speaking undergraduate students (36 females, 4 males) from McMaster University. Participants had a mean age of 19.6 years. Twenty-one participants identified as bilingual, but all were recruited as being native English speakers. Ethics approval was received from the McMaster University Ethics Board, and signed consent was obtained from all participants. Course credit was given in exchange for participation.

**Materials**

Participants completed two testing sessions. They were given the same TOT test in both sessions. The test consisted of 80 definitions (Warriner & Humphreys, 2008). There were 70 critical definitions for low frequency words, which were designed to elicit a TOT state (See appendix A). There were also 10 fake definitions. Participants were told there were fake definitions, which had no answer. The addition of fake definitions was to ensure that participants were in a true TOT state, by encouraging participants to report when they did not know an answer.

**Procedure**

On Day 1, the experimenter explained to participants that they would see definitions of words, and each time they saw a definition they would be asked if they knew the answer, did not know the answer, or if they were in a TOT state. They were told “a tip-of-the-tongue state is the feeling of knowing you know a word, but you are unable to say it”. Participants were also instructed and encouraged to speak aloud throughout the entire experiment. If participants could not think of the target word, they were told to verbally report any accessible information about the word, e.g., the first letter of the word, number of syllables, or any words that came to mind.

 The definitions were visually displayed on a 19 inch ViewSonic Professional series P95f+ CRT colour monitor controlled by a Dell Dimension 4600 computer. Spoken responses were recorded electronically via a hand held microphone. Stimuli were presented, and key-press responses recorded, using Presentation® (v.13, neurobs.com) experimental software. The experiment began with written instructions presented on the screen, which included the definition of a TOT state.

 **TOT test 1***.* Each trial began with the visual presentation of a definition. The keyboard buttons were labeled “Know”, “Don’t Know”, and “TOT”. Participants pressed the button that corresponded with their response. Participants spoke aloud about the target words when in a “TOT” or “Don’t Know” state throughout the entirety of the experiment. See Figure 1 on page 33 for a schematic of the experimental procedure.

 All participants had a 15 second delay period when the response was “Don’t Know” or “TOT”. The definition of the target word remained on the screen for the 15 seconds. If the participants resolved their TOT during the 15-second delay, they were instructed to press the “Know” button. Participants were then prompted to say the word aloud. If the participants correctly produced the word during the 15-second delay after pressing the “Know” button, this was considered to be a Resolved TOT or Resolved Don’t Know response. If participants could not produce the target word by the time the delay period ended, these trials were labeled unresolved. Participants were shown the correct answer at the end of each trial and were asked if that was the word that had been thinking of. If the definition was a fake, it was revealed to participants that there is no corresponding word to the definition.

 **TOT test 2**. The second TOT test was identical to the first TOT test. The second testing session was one week after the first. Definitions were randomized in both testing sessions. An experimenter was present for both testing sessions and actively encouraged participants to speak aloud. Each session lasted approximately 45 minutes.

**Results**

**Overall Response Likelihoods**

If a participant indicated that they knew a word or if a word was on the tip of their tongue and that the target word is the word they were thinking of, we can conclude that this is a valid Know or TOT trial. If they indicated that they did not know a word and that the target word was not the word they were thinking of, we classified this response as a valid Don’t Know.

 If a participant indicated that they knew a word or if a word was on the tip of their tongue and that the target word was not the word they were thinking of, we can conclude that this is an invalid Know or TOT trial. If they indicated that they did not know a word and that the target word was indeed the word they were thinking of, we classified this response as an invalid Don’t Know trial. By differentiating between valid and invalid trials we can be sure that our participants are experiencing a true Know, Don’t Know, or TOT state.

 This experiment has a total of 2800 pairs of trials collected from 40 participants for 70 definitions across two testing sessions. A trial pair contains the Test 1 response and Test 2 response for an individual target word. Of the 2800 pairs, 1788 were considered to be valid. A valid trial pair means that both the Test 1 and Test 2 response for a particular trial was valid. Of the 2800 Test 1 trials, 2058 were valid and of the 2800 Test 2 trials, 2296 were valid. This means that 1019 pairs of trials were excluded on the basis that they were invalid. Of all Test 1 Know responses, 26% (308/1175) were invalid, whereas 11% (169/1577) of Test 2 Know responses were invalid. Out of all Don’t Know responses, 14% (139/1018) of Test 1 responses and 16% (115/708) of Test 2 responses were invalid. Of all TOT responses 48% (292/604) of Test 1 TOT responses and 42% (216/511) were invalid. See Table 1 on page 34 for the valid response rates.

 All 40 participants experienced at least one TOT state on Test 1 (see Figure 2 on page 35). The number of TOTs per participant ranged between one and nineteen (out of seventy critical trials). Considering that we analyze our data by item, it is important to discern whether or not only a small subset of participants are contributing to the overall TOT rate. Since all participants experienced a TOT state, we can conclude that this is not the case.

**Repeated TOT States**

We looked at the tendency for TOT states to repeat for individual words on Test 1 and one week later on Test 2. Twenty-eight out of 40 participants experienced at least one repeated TOT state. We also looked at resolved and unresolved TOT states on both Test 1 and Test 2. After collapsing across resolved and unresolved responses, we found that 27% (84/312) of the TOT states experienced on Test 1 were repeated on Test 2.

A log odds ratio statistic was calculated to examine the difference between conditional probabilities of Test 2 response given a Day 1 response. The odds ratio (OR) in this case is the odds of experiencing a TOT on Test 2 versus a Know or Don’t Know response given a TOT or a non-TOT for an individual word on Test 1. The odds ratios were calculated by creating a dichotomous variable that differentiated between a TOT and non-TOT response, which was composed of Know and Don’t Know responses. If an OR is equal to 1 this shows that there is no increased likelihood of having a TOT on Test 2 given that there was a TOT on Test 1. The OR for Test 2 TOTs given a Test 1 TOT response versus non-TOT response was 4.84 with the lower and upper limits of a 95% confidence interval of 3.53 and 6.64 (*z* = 9.79, *p* < .01). Note we report the OR rather than log OR, for readability purposes. The OR of 4.84 means that the odds of repeating a TOT on Test 2 were almost five times greater if one experienced a TOT on Test 1 rather than a non-TOT response. These statistics mean that TOT states repeat for individual words at a rate greater than chance than all other responses.

Considering only TOT states that were not spontaneously resolved, unresolved TOTs repeated at a rate greater than chance (OR = 7.29, 5.11 – 10.42, *z* = 10.94, *p* < .01). This means that the odds of a TOT repeating on Test 2 for an individual word was over seven times greater if an unresolved TOT was experienced on Test 1 as compared to all other responses.

Next, we looked at the effect of self-resolution of TOT states during the trial. Consistent with the “resolution effect” described by D’Angelo and Humphreys (2015), the probability of experiencing a TOT on Test 2 given that a TOT was left unresolved on Test 1 is 0.41 in comparison to a resolved TOT, which is only 0.15. This means the recurrence of a TOT depends on whether or not a TOT state is resolved on Test 1. The odds of a TOT state repeating on Test 2 for an individual word is almost four times greater if there was an unresolved TOT on Test 1 as compared to a resolved TOT, i.e., successfully finding the answer on one’s own (OR = 3.98, 2.18 – 7.26, *z* = 4.51, *p* < .01). See Table 2 on page 36 for the odds ratio for the difference between resolved and unresolved Test 1 TOTs and conditional probabilities that were calculated for Test 2 responses given a Test 1 response.

**Interloper Coding Scheme**

Utterances were first transcribed and then coded as semantic or phonological. An utterance is considered to be semantic if the speaker produces a word that is related in meaning to the target word. We also coded utterances from episodic memory as semantic. An utterance is considered to be phonological if the speaker produces an utterance that has an alternative word that is related to in sound the word. Also within the phonological category is partial phonological, onset cluster, first syllable, first and second syllable, and orthographic utterances. All other responses were coded as unrelated. Semantic utterances occurred when a participant uttered a word that was related in meaning to the target word, e.g., “nectar” from the target word pollen. Partial sounds derived from the target word were coded as partially phonological, e.g., “something scope” from kaleidoscope. An onset cluster utterance occurred when the speaker was able to think of the onset of consonants in which a vowel is absent, e.g., “ch” from chalice. An example of a first syllable is “pro” from procrastinate and an example of first + second syllable is “aba” from abacus. An orthographic utterance occurred when the speaker was able to provide information about the written form of the word, e.g., “It starts with an ‘a’” for the target word arson. An utterance coded as “episodic memory” means the speaker was able to remember information related to the target word such as a time, place, or context in which they encountered the target word, e.g., “It was in the Hiroshima book I read about the Japanese girl” for the target word origami. An example of an unrelated utterance is “billboard” for planetarium. We collapsed across semantic and episodic memory as semantic interlopers, and collapsed across phonological, partial phonological, onset cluster, first syllable, first and second syllable, and orthographic utterances as phonological interlopers. We note that in some cases a TOT state may be elicited from a trial definition for a word that is not the target word. In these cases we may not know the word the participant is thinking of, therefore making it impossible to know whether or not the phonological information provided is related or not.

 **Repeated Interlopers**

We looked at the tendency for interlopers—persistent information that comes to mind—to repeat for individual words. Participants were given 15 seconds to think aloud about the target word during a Don’t Know or TOT state. The mean length per utterance was 14.5 words. We calculated the proportion of trials with repeated information on Test 2. Only paired trials that had the same response on Test 1 and Test 2 are reported here, i.e., Don’t Know Test 1/Don’t Know Test 2 for an individual target word and TOT Test 1/TOT Test 2 for an individual target word. Participants were not given 15 seconds to think aloud if they knew the word, so Know responses are excluded from this analysis. The proportion of paired trials with repeated information was larger for TOT trials than Don’t Know trials. Proportion of trials with repeated information was calculated by dividing the number of trials with the exact same repeated information uttered by the total number of TOT or Don’t Know trials that were repeated on Test 2. The proportion of recurring TOT trial pairs with repeated information was 26% (22/84). In contrast the proportion of Don’t Know trials with repeated information was 13% (57/423) (OR = 2.28, 1.30 – 3.99, *z* = 2.88, *p* = .004).

**Interloper Type**

 Participants reported phonological information 7% (63/879) of the time for Test 1 Don’t Know trials and 34% (105/312) of the time for Test 1 TOT trials (OR = 6.57, 4.64 – 9.30, *z =* 10.61, *p* *<* .01). We also looked at the nature of the information that was being repeated; repeated interlopers were coded as phonological or semantic. There were 50 paired Don’t Know trials that included only repeated semantic information, 2 trials that included only repeated phonological information, and 5 trials that included both repeated semantic and phonological information.

 The paired TOT trials included 9 trials that included repeated semantic information and 12 trials that included repeated phonological information, and one trial that included both semantic and phonological information (see Table 3 on page 37 for the 13 repeated TOT trials with repeated phonological interlopers). We note that two of the paired TOT trials produced incorrect phonological (javelin and ornithology). We speculate that although repeated phonological interlopers are not always correct, there is sometimes some random noise within the word production system that leads a speaker down a specific erroneous phonological pathway. We know that participants were indeed in a TOT state for these words as we asked them at the end of each trial if the target word is the word they had in mind, to which the participants said yes.

 Out of the 22 paired TOT trials, 7 trials included a repeated alternative word that was semantically related to the target word. Two trials with repeated semantic information consisted of information from episodic memory, e.g., “There’s one here at McMaster University” for the target word ‘planetarium’. See Table 4 on page 38 for the number of interloper types for repeated Don’t Know and TOT trials.

 It is important to note that the critical finding here is not how large the number of trials is, but the difference between semantic and phonological information for Don’t Know trials in comparison to the difference between semantic and phonological trials for unresolved TOTs. Participants reported phonological information on 12% (7/57) of paired Don’t Know trials with repeated information and on 59% (13/22) of paired TOT trials with repeated information (OR = 10.21, 3.27 – 31.92, *z =* 3.99, *p* < .01). We acknowledge that the likelihood of phonological interlopers repeating could be due to chance. Contrary to the idea that these findings are due to chance, the likelihood of having specific phonological information repeat becomes vanishingly small if we look at statistical theory, specifically type 2 error.

Note that the difference between semantic and phonological information type is much smaller for the unresolved TOT responses. If one is in an unresolved TOT state they will experience phonological interlopers more than if they were in a Don’t Know state. It is also important to note that the majority of trials with repeated information for the Don’t Know trials include alternative words, whereas the majority of TOT trials with repeated information include partial phonological information directly related to the target word. There was also only Don’t Know trial that included correct partial phonological information related to the target word.

**Discussion**

**Central Findings**

 The results show that not only do errors repeat one week later for individual words but that interlopers and reports of partial information also repeat. The tendency for TOTs to repeat at a rate greater than can be predicted by chance is consistent with findings in the literature (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Furthermore, we also replicated the finding previously referred to as the resolution effect, in that TOT states that were self-resolved do not tend to repeat nearly as often as unresolved TOT states do, despite being told the correct answer in all cases. The central finding of this paper is that when using a think aloud protocol, asking speakers to verbalize any information that comes to mind when they are trying to retrieve a word, if a TOT repeats a week later, the same interlopers or partial information often repeats at that time as well; this is over twice as likely for TOTs than Don’t Know Trials. When participants resolve a TOT, they get double exposure to the target word from thinking of the word on their own, in addition to being shown the answer. It is plausible that resolved TOT trials are less likely to repeat than unresolved TOT trials due to the simple explanation of there being more exposures to the target word during a resolved TOT trial. Subsequently, the strengthening of the target word through exposure could make one less likely to repeat a TOT state on Test 2. Although we cannot completely rule out this explanation with these data, one point is that mere exposure cannot explain the fact that TOT states tend to repeat, as Don’t Know Trials do not repeat in the same way as unresolved TOT states, despite the same amount of exposure at Test 1.

These findings demonstrate the importance of the role of phonology in the TOT state. While both Don’t Know and TOT responses in the think aloud protocol frequently contained semantic or episodic information, only the TOT responses showed sizable reports of (usually accurate) phonologically related information. However, this is possibly tautological, in that the presence of consciously available phonological information may make a participant much more likely to describe their state as a TOT rather than a Don’t Know. It is worthwhile to note however, that available semantic or episodic information does not appear to affect this metacognitive judgment.

The fact that the same information, especially phonologically related material, was reported a week apart on repeated TOT trials speaks directly to our hypothesis about what is being learned in the error state. This finding supports the idea that the TOT state may be best described as an organized pattern of activation, providing an opportunity for convergence on an erroneous state (although as mentioned earlier, this is currently a statistical pattern rather than a systematic one). The retrieval effort, especially a repeated one over a period of 15 seconds then reinforces the mapping from lemma to that specific incorrect phonological state. Then, during a subsequent retrieval attempt, that incorrectly reinforced mapping is then followed, leading to the same (or at least highly similar) erroneous state, complete with repeated partial information. The learning via Hebbian reinforcement of a specific alternate state also provides a more plausible mechanism underlying an error learning explanation of the error repetition effect. However, we cannot say how this is likely to be the case for all TOT states. It could be common to all, but only occasionally consciously available via introspection, or alternatively may only associate with the subset of cases in which the information is in fact consciously available.

**Limitations and Future Directions**

First, there is an alternative possibility that we cannot completely rule out. That is, it is possible speakers repeat partial information not because they are in the same erroneous state during a subsequent recall attempt, but that they are able to explicitly recall the partial information that they were able to come up with a week previously (while still being unable to recall the correct word they had been presented with after their initial TOT, and had verified as their intended target). Future studies should address this possibility.

Second, the numbers reported here tend to be small, as a result of looking at relatively rare error events (which is generally a commonality across all TOT studies), with further diminished numbers by looking at joint probabilities of two of these error events, and furthermore, dividing the classification of the think aloud responses into many different subcategories of type of information. The true rates of each of the subclassifications within recurring errors are therefore difficult to estimate.

**Conclusion**

However, the overall patterns are quite clear: when TOT errors repeat, accompanying partial information can be observed to repeat as well, and TOTs show a much larger proportion of repeated phonological information than Don’t Know responses. To be clear, Don’t Know responses did not necessarily have no information whatsoever; it is possible that participants in a Don’t Know state might have been experiencing a feeling of knowing or deriving semantic information from the definitions. In these cases participants did not know the word and were not in a TOT state as we designated it. In this context, we stress the importance of how differently phonological information is distributed across TOT and Don’t Know responses. We argue that this suggests a fairly organized erroneous pattern of phonological activation within a TOT state, to which a mapping from the lemma level can be reinforced via a Hebbian-type learning mechanism, giving rise to the learning of TOT errors.



**Figure 1.** Schematic of a trial used on TOT Test 1 and 2.

Table 1: Overall response rates.

|  |  |  |  |
| --- | --- | --- | --- |
| Test 1 Responses | Proportion  | Test 2 Responses | Proportion |
| Know | .42 | Know | .61  |
| Don’t Know | .43 | Don’t Know | .26 |
| TOT | .15 | TOT | .13 |
|  |  |  |  |

**Figure 2:** Count of Number of Test 1 TOT States.

Table 2: Cross-tabulation of Test 1 and Test 2 responses.

 Test 2 Responses

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test 1 Responses | Know | Don’t Know | TOT | Total | Conditional Probability *a* | Odds Ratio |
| Know | 815 | 5 | 32 | 852 | .04 |  |
| Don’t Know | 142 | 423 | 90 | 655 | .14 |  |
| TOT Resolved | 98 | 1 | 17 | 116 | .15 |  |
| TOT Unresolved | 86 | 12 | 67 | 165 | .41 | 3.98\* |

*a* Conditional probability of experiencing a TOT on Test 2.

The odds ratio compares the likelihood of a resolved TOT to repeat versus an unresolved TOT to repeat. Odds ratios are calculated from a dichotic variable of Test 2 TOT versus another Test 2 response.

\**p* < .01

Table 3: Phonological interlopers for repeated TOT responses.

|  |  |
| --- | --- |
| Target | Interloper |
| abdicate | a |
| ornithology | o |
| slalom | s |
| metronome | m, me |
| javelin | s |
| ellipsis | e |
| ornithology | a |
| onomatopoeia | o |
| kaleidoscope | something scope |
| planetarium | planetorium |
| pseudonym | s |
| odometer | spedometer |
| vineyard | v |

Table 4: Count of interloper type for DK and TOT responses.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Interloper Type |  |  |  |  |  |
| Trial Pair Response | Alternative Semantic Word | Episodic Memory | Partial Phonology | Orthographic | Alternative Phonological Word | Alternative Semantic + Phonological Word | Total |
| Don't Know | 48 | 2 | 1 | 1 | 0 | 5 | 57 |
| TOT | 7 | 2 | 1 | 10 | 1 | 1 | 22 |

**Chapter 3 - Age is Associated with Recurring Tip-of-the-Tongue States Above and Beyond Cognitive Functioning**

The tip-of-the-tongue (TOT) state is the feeling that one knows a word but yet that word’s pronunciation cannot be retrieved from memory. Older adults tend to experience more tip-of-the-tongue (TOT) states than young adults (e.g., Brown & Nix, 1996; Burke, MacKay, Worthley &, Wade, 1991; Dahlgren, 1998; Farrell & Abrams, 2011; Heine, Ober, & Shenaut, 1999; Juncos-Rabadan, Facal, Rodriguez & Pereriro, 2010; Rastle & Burke, 1996; Salthouse & Mandell, 2013). Anecdotally, TOT states are concerning for some older adults as an increase in TOT states may be interpreted as a sign of cognitive decline. Theoretically, there is uncertainty surrounding why older adults experience more time in a TOT state and to what extent the TOT state is associated with normal aging. TOT states are hypothesized to be reflective of a specific phonological failure (e.g., Burke, MacKay, Worthley &, Wade, 1991). In this paper, we build our arguments upon the phonological failure hypothesis.

**TOT States in Older Adults and the Two-Stage Model of Word Retrieval**

Successful word production (based on Dell’s 1986 model of word production) occurs when there is activation of non-linguistic conceptual information, which then maps onto lexical information (the lemma level). Lexical information is then mapped onto phonology, followed by articulation. When one enters a TOT state, it is hypothesized that there is a deficit in the transmission of activation between the lemma and phonology. In older adults, this may occur frequently due to overall weakened associations within the language production system, along with frequency and recency effects (Burke et al., 1991). Phonology is hypothesized to be particularly susceptible to weakening due to the many connections that converge onto the semantic network, but only single connections that diverge onto phonology (as described in Abrams & Farrell, 2010; Burke & Shafto, 2008; Mortensen, Meyer, & Glyn W. Humphreys, 2006).

**Dementia and TOT States**

 It has been well established since the early twentieth century that language production decline is a marker of dementia of the Alzheimer’s type (DAT; Alzheimer, 1907). Looking at the general frequency of TOT states, Salthouse and Mandell (2013) found that age-related increases in TOT states were not significantly associated with episodic memory impairments. Astell and Harley (1996) found that older adults with probable DAT knew fewer words, experienced more TOT states, and produced more semantically related words than controls. Production of semantically related targets is more indicative of not knowing the word than a TOT state. It is possible that older adults with DAT were reporting a TOT state when they did not know the word. Astell and Harley’s (1996) findings are consistent with the hypothesis that those with DAT show more weakening of connections at the semantic level than do neurologically intact older adults.

**Repeated TOT States in Young Adults**

As an extension to the Transmission Deficit Hypothesis (Burke et al., 1991), Karin R. Humphreys and colleagues in their work on repeated TOT states have also focused on the connections between lemma and phonology as the locus of the effect. Young adults repeat the same TOT states at a rate greater than can be predicted by chance, which has been termed the *error repetition effect* (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). When a TOT is experienced for a word, a TOT state is likely to repeat for that same word again.

They argue that not only is there a faulty transmission of activation between the lemma and phonology stage of word production during a TOT state, but that there is reinforcement of this erroneous pathway each time the speaker enters the same TOT state, leading to an increased likelihood that one will enter that TOT state for the same word in the future. That is, it is argued to be not just a *repetition* effect*,* but also an *error learning* effect. Reinforcement of the erroneous pathway could be explained through a Hebbian-like learning mechanism in that the word production system is adjusted with experience. If young adults are more likely to experience a repeated TOT state for a specific word, then what happens to older adults, who are already at risk for experiencing an increase in TOT states? And what happens to older adults who have probable dementia?

**Repeated TOT States in Older Adults**

Presently Middleton and Schwartz (2013) has been the only study to investigate the error repetition effect in older adults. They explored error repetition in older adults with and without aphasia. Participants were taught how to actively search for the words by either thinking of phonological information related to the target word or semantic information related to the target word.

Middleton and Schwartz (2013) did not observe an error repetition effect in either group following a semantic self-cuing strategy. This is not surprising if TOT states do not occur at the conceptual-to-lexical stage of word production, and is consistent with the lemma-to-phoneme locus suggested by Humphreys and colleagues. In contrast, when using a phonological self-cuing strategy, those with aphasia showed a significant rate of error repetition, but control participants did not. This finding in control participants is different from that of Warriner and Humphreys’ (2008) study on the error repetition effect in young adults. Using a phonological cuing strategy (ruminating on a phonological search for the word) should strengthen erroneous lemma-to-phonology connections, leading to more repeated TOT states (Middleton & Schwartz, 2013).

Critically, there is a fundamental difference in the way the results were analyzed between the two studies, which obscures the presence of error repetition. Specifically, Middleton and Schwartz (2013) analyzed differences in the proportion of repeated TOT states between conditions. We argue that these proportions do not capture how an individual experiences a repeated TOT state. Specifically, Humphreys and colleagues hypothesize that a Test 2 TOT state is dependent on the Test 1 response, which is not possible to discern from analyzing the general difference in number of repeated TOT states between conditions. Therefore, TOT repetition should be defined as the recurrence of an individual TOT state at a rate greater than can be predicted by chance. The current study therefore sought to determine if an error repetition effect is present in older adults using similar materials and methodologies as those used in Warriner and Humphreys (2008) and D’Angelo & Humphreys (2015).

Idiosyncratic difficulty of particular items may contribute to the tendency for TOT states to repeat for those items. A speaker may experience a TOT state for a difficult word and in turn may be likely to report a TOT state for that same word the next time it is encountered. Word difficulty cannot account for all of the error repetition effect. For instance, Warriner and Humphreys (2008) found that young adults who are given more time to actively search for the target word are more likely than can be predicted by chance to have a recurring TOT state than those participants who were only given a short amount of time to search for the target word. They argued that this is evidence for the strengthening of erroneous lemma-to-phonological connections. While this paper does not specifically explore error learning mechanisms in TOT states, see D’Angelo and Humphreys (2015) for an in depth discussion on error learning.

**Errorless Learning in Older Adults with DAT**

Errorless learning has been demonstrated to be a promising form of psychological intervention for patients with DAT, which is the practice of minimizing mistakes or error during any type of training (e.g., Clare, Wilson, Carter, Breen, Gosses, & Hodges, 2000; Terrace, 1963). Errorless learning is hypothesized to occur through implicit memory, which is in line with the error learning mechanism proposed by Humphreys and colleagues (Page, Wilson, Shiel, Carter, & Norris, 2009). Furthermore, Laffan, Metzler-Baddeley, Walker, and Jone (2010) found that when responses are self-generated, errorless learning is improved, which is consistent with the resolution effect whereby speakers are less likely to enter a TOT state if they self-resolved their TOT state the first time (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). As mentioned, entering an erroneous TOT state makes one more likely to enter that same erroneous state, arguably through a Hebbian-like learning mechanism (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). While the exploration of errorless learning is not the objective of this study, it is important to note that the cognitive theory outlined in this paper may be the underlying mechanism driving errorless learning in the context of the word production system.

**Current Study**

 Our goal was to determine if the error repetition effect—the tendency for TOT states to repeat at a rate greater than can be predicted by chance—occurs in older adults. Considering that dementia is often a concern for older adults, we wanted to determine if the error repetition effect is a normal part of healthy aging.

 We hypothesized that older adults would experience the error repetition effect. We also hypothesized that age would predict the probability of repeating a TOT above and beyond cognitive functioning. Our reasoning is that in the absence of cognitive impairment beyond that expected in normal aging, an aging (but healthy) word production system should theoretically function similarly to that of a young adult. Older adults may be more susceptible to the error repetition effect (i.e., repeated TOT states) due to general weakening of the word production system over time, but theoretically, repeated TOT states should not be indicative of dementia, as there is more linguistic access during a TOT state than not knowing a word at all.

 Based on previously mentioned literature, a word production system affected by dementia may deteriorate to the point where repeated TOT states are less likely to occur. If the general likelihood of entering a TOT state decreases due to deteriorating semantic connections, which would in turn prevent successful lexical activation, then we expect the likelihood of re-experiencing that same TOT to decrease with time. That is, TOT responses in older adults with dementia will turn into Don’t Know responses with time. As dementia progresses, the semantic connections become increasingly weak, leading to fewer repeated TOT states.

**Methods**

**Participants**

 Participants included 36 English-speaking adults (25 females, 11 males) living in retirement homes in Canada ranging in age from 63 to 96 with a mean age of 85.3. This sample size was comparable to past repeated TOT studies that have observed an error repetition effect.Eleven participants had fewer than twelve years of education, nine participants had graduated high school, and twenty-five participants had post-secondary education. Ethics approval was received from the McMaster University Ethics Board. Both signed and verbal consent was obtained from all participants. In some cases where staff at the residences knew of a lack of ability to give fully informed consent, consent was obtained from both the participant and a designated family member. Participants were each given a small gift as a token of appreciation.

**Materials**

 **Cognitive impairment***.* All participants were administered the Montreal Cognitive Assessment (MoCA; Nasreddine, 2005). The MoCA is a 30-point standardized screening tool used to detect mild to severe cognitive impairment, and typically took between 10-15 minutes to administer. A score of 26 or higher was considered to be normal. A score between 18 and 26 indicates the presence of mild dementia, 10-17 indicates moderate dementia, and 1-9 indicates severe dementia. MoCA scores ranged from 12 to 30 with a mean of 22.39. Twelve participants tested in the normal range, 17 in the mild range, and 7 in the moderate range. Rather than group participants as normal versus probable dementia, this paper focuses on how repeated TOT states change on the continuum of cognitive functioning.

 **Vocabulary***.* All participants were administered the Peabody Picture Vocabulary Test (PPVT). The PPVT is a standardized measure of receptive vocabulary for English speakers. The mean PPVT percentile was 70.24 with a range of 32nd to 99th percentile.

**Experimental Measures**

Testing took place at several retirement residences. Participants were administered a TOT task, which consisted of 42 definitions used by Warriner and Humphreys (2008), e.g., “What do you call the three leaf clover that is the emblem of Ireland?” for the target word ‘shamrock’ (see appendix). The task also included 10 fake definitions, e.g., “What do you call a pencil with a decorative animal on the end?”. There were 10 fake definitions to ensure that participants were in a true TOT state by encouraging them to report that they did not know the answer.

**Procedure**

 On Test 1, the experimenter explained to the participant that they would be shown definitions one at a time, and to indicate whether they knew the word, did not know the word, or if the word was on the tip of their tongue. They were told “a tip-of-the-tongue state is when you know that you know the word, but you cannot get the sounds out to say it”. If the participant was having difficulty understanding what a TOT state is, the experimenter sometimes asked “Does it feel like the word is on your tongue or in the back of your head?”. This explanation was easier for some participants to understand. Participants were also encouraged to actively search for the word during a 15s time interval if they were in a TOT state.

 The definitions were presented on paper using a binder, as some participants were not comfortable using a laptop. Definitions were presented in large, bold print to accommodate for visual impairment. In some cases of severe visual impairment, the experimenter read the definitions aloud to the participant.

**TOT test 1***.* Each trial began with the visual presentation of a definition.. Participants were encouraged to speak aloud if in a TOT or Don’t Know (DK) state for 15 seconds (see Figure 3 on page 56 for a schematic of the experimental procedure). If participants thought of the word during the 15 seconds, they informed the experimenter verbally. At the end of each trial, the experimenter told the participant the answer, to which the participant indicated verbally whether or not that was the word they had been thinking of. All responses were recorded on paper by the experimenter or an assistant.

 **TOT test 2***.* The same experiment was administered 48 hours later. The only difference was that participants were not given time to resolve their answer if in a TOT or DK state. Each session lasted approximately one hour.

**Results**

**Overall Response Likelihoods**

This experiment had a total of 1512 trial pairs collected from 36 participants for 42 definitions across two testing sessions. There were 1039 valid trial pairs used in our analyses. A Know or TOT trial was considered to be valid if the target word was the word they were thinking of. If the participant indicated they did not know the word and the target word really had not been the word the participant was thinking of, the trial is valid. Using this method, we can differentiate between true and false Know, DK, and TOT states.

 This does not mean there are 1039 valid Test 1 trials and 1039 valid Test 2 trials. There were 1118 valid Test 1 trials and 1308 valid Test 2 trials. Also note that although the sum of the valid Test 1 trials plus Test 2 trials equals 2426, this does not mean there are 2426 valid trial pairs. For a trial pair to be considered valid, both the Test 1 and Test 2 response for a specific trial had to be valid, of which there were 1039.

 Participants correctly recalled the target word for 50% (564/1118) of valid Test 1 trials and 65% (846/1308) of valid Test 2 trials. Participants did not know the word for 32% (361/1118) of the valid Test 1 trials and 24% (318/1308) of valid Test 2 trials. Participants were in a TOT state on 17% (193/1118) of the valid Test 1 trials and 11% (144/1308) of the valid Test 2 trials. Participants resolved 33% (63/193) of their valid TOT states on Test 1. Participants did not resolve any Don’t Know states.

**Repeated TOT States**

The probability of experiencing a TOT state on Test 2 given an unresolved TOT state on Test 1 (i.e., did not think of the answer on one’s own) was .30. The probability of experiencing a TOT state on Test 2 given that one resolved their TOT state on Test 1 (i.e., thought of the answer on their own) was only .14. If one knew the word or did not know the word on Test 1, the probability of experiencing a TOT state on Test 2 was .06 and .09 respectively.

 A log odds ratio statistic was calculated to examine if the conditional probability of a Test 2 TOT given a Test 1 TOT differed significantly from the conditional probability of a Test 2 TOT given some other Test 1 response. The ORs were calculated by creating a dichotomous variable that differentiated between a TOT and non-TOT response, which was composed of the sum of Know and Don’t Know responses. The odds ratio (OR) was defined as the odds of experiencing a TOT on Test 2 versus a Know or Don’t Know response given a TOT or a non-TOT for an individual word on Test 1. An OR equal to 1 means there was no increased likelihood of experiencing a TOT state on Test 2 given that there was a TOT on Test 1. For clarity, we will report the OR rather than the log OR.

 The OR for a Test 2 TOT state given a Test 1 TOT response versus not-TOT response was 4.16 with the lower and upper limits of a 95% confidence interval of 2.70 and 6.41 (*z* = 6.47, *p* < .001). An OR of 4.16 means that participants were over four times more likely to repeat an individual TOT state on Test 2, if they experienced a TOT state for the same word on Test 1 as compared to all other responses (Know and Don’t Know). Unresolved Test 1 TOT states also repeated at a rate greater than can be predicted by chance (OR = 5.17, 3.24 – 8.27, *z* = 6.87, *p* < .001). This result indicates that the odds of repeating an individual TOT state that was left unresolved on Test 1 was over five times greater than if the participant knew the word, did not know the word, or resolved their TOT state on Test 1.

 The resolution effect occurs when a TOT state is much less likely to repeat if the TOT state was self-resolved as compared to unresolved on Test 1 (D’Angelo & Humphreys, 2015). As previously mentioned, the probability of a recurring TOT state on Test 2 given that the TOT state was left unresolved on Test 1 was .30, and was only .14 if the TOT state was resolved on Test 1. We argue that the error repetition effect is dependent on whether or not the TOT state was left unresolved on Test 1. The odds of a TOT repeating on Test 2 if the TOT state was left unresolved on Test 1 was almost three times greater than if the TOT state was resolved on Test 1 (OR = 2.70, 1.14 – 6.24, *z* = 2.27, *p* = .02). Table 5 on page 57 lists the odds ratio for the difference between resolved and unresolved Test 1 TOTs and conditional probabilities that were calculated for Test 2 responses given a Test 1 response.

**Age and Repeated TOT States**

We first determined the simple rate of TOT states on Test 1. The correlation between the number of Test 1 unresolved TOT states and age was non-significant, *r*(34) = .29, *p* = .08, although numerically in the expected direction. Although this finding is seemingly inconsistent with past literature that shows a general increase in TOT states with age, our finding is more likely due to a restriction in age range.

 The individual conditional probabilities of repeating a TOT state on Test 2 given an unresolved TOT state on Test 1 were significantly positively correlated with age (*r*(27) = .42, *p* = .02). Figure 4 on page 58 shows a scatterplot showing the relationship between age and repeated TOT states. Note that the linear correlation is necessarily attenuated because of the ceiling in age.

**Montreal Cognitive Assessment Scores and Repeated TOT States**

We examined the relationship between Montreal Cognitive Assessment (MoCA) scores and error repetition. Considering only Test 1 responses, MoCA scores were strongly positively correlated with Know responses (*r*(34) = .68, *p* < .001) and negatively with Don’t Know responses (*r*(34) = -.53, *p* = .001), but there was no significant correlation between MoCA scores and unresolved TOT responses (*r*(34) = -.3, *p* = .07). It may appear that the correlation between MoCA scores and unresolved TOT responses is on the cusp of significance, but it appears there are two data points driving this correlation (see Figure 5 on page 59).[[1]](#footnote-1)

 Excluding two outliers, the correlation between MoCA scores and unresolved Test 1 TOT responses was only *r*(32) = -.12, *p* = .49. Outliers were calculated using the absolute deviation around the median using a moderately conservative cutoff value of 2.5, which is a more robust method of outlier detection than using the standard deviation around the mean (Leys, Ley, Klein, Bernard, & Licata, 2013). There remained a moderate positive correlation between MoCA scores and resolved TOT responses, *r*(33) = .45, *p* < .01. MoCA scores were also not significantly correlated with the conditional probability of repeating a TOT state on Test 2 given an unresolved TOT state on Test 1, *r*(27) = -.24, *p* = .22 (see Figure 6 on page 60).

**Association Between Age and MoCA**

 It is plausible that the significant correlation between age and repeated TOT states was due to cognitive functioning as measured by MoCA scores. However, we did not find this to be the case as the correlation between age and MoCA was quite weak at *r* = -.16. Furthermore, a multiple linear regression using block-wise selection was calculated to determine if age is the best predictor of repeated TOT states while controlling for MoCA (and vice versa). With age alone, we found a significant regression equation (F(1, 27) = 5.80, *p* = .02) with an R2 of .177. Repeated TOT states increased by a probability of .017 for each increase in standard deviation of age. When MoCA was added to the model there was a small change from an R2 of .177 with age only to .201 with both age and MoCA. Even when MoCA was added after age, age remained a significant predictor of repeated TOT states (an increase of a probability of 0.016 for every unit of age).

 Critically, age remained a significant predictor of repeated TOT states above and beyond the MoCA after age was entered into the model last. Age still predicted repeated TOT states by an increase in probability of .016 for every increase in standard deviation of age.

**Vocabulary Scores, Education, and TOT States**

The mean PPVT percentile was 70.24. Twenty-nine out of thirty-six participants completed the PPVT. The remaining seven participants had visual impairment and therefore could not complete the PPVT. We found that PPVT percentiles were significantly positively correlated with the number of Test 1 Know responses (*r*(27) = .57, *p* = .001) and negatively with Test 1 Don’t Know responses (*r*(27) = -.62, *p* < .001). Vocabulary scores and the number of Test 1 unresolved TOT states were not significantly correlated (*r*(27) = .11, *p* = .56). Vocabulary scores were not correlated with the conditional probability of a repeated TOT on Test 2 given an unresolved TOT on Test 1 (*r*(20) = .15, *p* = .51).

 We also wanted to ensure that education level did not influence the number of TOT states one experienced. The correlation between education as measured by level (less than high school, high school, post-secondary) and the number of Know, Don’t Know and TOT responses was non-significant. Education was not measured in number of years as some participants could not reconstruct this specific information, but all participants knew the level of education completed.

**Discussion**

**Central Arguments**

 **TOT states tend to repeat in older adults.** We found that older adults were significantly more likely to re-experience a TOT state 48 hours after Test 1 if the TOT state was left unresolved on Test 1, despite being told the correct answer the first time. We also found that older adults who self-resolved their TOT state on Test 1 were significantly less likely to re-experience the same TOT state on Test 2 as compared to the TOT state being left unresolved on Test 1. This is the same error repetition pattern that we have observed in young adults (D’Angelo & Humphreys; Warriner & Humphreys, 2008). Our results are strong evidence to support that older adults show the same kinds of error repetition patterns as those found in young adults.

 **TOT states are not a bad thing.** After partialing out the MoCA scores, we found that age remained a significant predictor of the tendency for TOT states to repeat. That is, as age increased, the tendency to repeat a TOT state for a specific word increased. MoCA scores were not found to be significantly associated with repeated TOT states. This finding shows a dissociation between having a TOT for a particular word in the first place (linked with measures of cognitive ability), and the subsequent increased tendency for that same TOT state to repeat (related to age but independent of cognitive ability). This is strong evidence to suggest that repeated TOT states are not driven by cognitive impairment, but are rather a part of normal aging.

 We did not attempt to diagnose dementia with the MoCA due to its limitations and use as a screening tool that measures cognitive impairment caused by a wide array of conditions. Due to the age of our participants, we can infer that a low MoCA score is most likely caused by the presence of dementia. Furthermore, the MoCA correlates strongly with multiple variables in this data-set, allowing us to infer that it has at least adequate reliability, as well as an adequate range of values.

**Errorless Learning**

 According to our theoretical arguments, an errorless learning type of guiding principle in language intervention would be most beneficial during the earlier stage of DAT as the lemma to phonological units are still strong enough to change with experience. We have also derived this hypothesis from Laffin et al.’s (2010) study, given that they found errorless learning principles to work better in those with less severe compared to severe cognitive dysfunction. We predict that the significant weakening of conceptual to lexical nodes would make errorless learning a much less effective intervention strategy for patients with more advanced dementia, giving patients fewer opportunities to change their word production system with experience.

**Future Directions**

 We acknowledge that further work must be undertaken to determine the specific mechanism underlying repeated TOT states in older adults. However, if we assume that the repeated TOT mechanism is similar to that found in young adults, we think it is logical to hypothesize that the error repetition effect in older adults may be due to an error learning mechanism. In future studies, we plan to study repeated TOT states in older adults using a timing manipulation and cuing manipulation similar to those used in D’Angelo and Humphreys (2015) and Warriner and Humphreys (2008). However, the data in this paper serve as an important first step for understanding the error repetition effect in older adults. Experiments of this nature can be quite mentally and/or physically taxing on older adults with both cognitive and physical difficulties, so we recommend a strict screening process if experimental manipulations are to be implemented.

**Conclusions**

 The increasing conditional probability for TOT states to repeat with increasing age may be due to weakening connections between lemma and phonology, as phonological connections are hypothesized to be particularly vulnerable to aging. If we assume a lemma-to-phonology failure, weakening of phonological connections may be a normal part of aging as demonstrated by the increase in recurring TOT states with age, but not with MoCA scores. More serious issues arise when there is evidence of significant weakening between the conceptual and lexical levels of word production (i.e., an increase in Don’t Know responses), which may be a sign of cognitive impairment beyond that expected in normal aging. Repeated tip-of-the-tongue states may be irritating but are not necessarily a bad thing.



**Figure 3.** Schematic of trial used on TOT Test 1*.* Test 2 trials did not include 15s to think of the answer.

Table 5: Cross-tabulation of Test 1 and Test 2 responses.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Test 2 Responses

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test 1 Responses | Know | Don’t Know | TOT | Total | Conditional Probability *a* | Odds Ratio |
| Know | 500 | 15 | 35 | 550 | .06 |  |
| Don’t Know Unresolved | 89 | 202 | 29 | 320 | .09 |  |
| TOT Resolved | 48 | 1 | 8 | 57 | .14 |  |
| TOT Unresolved | 61 | 17 | 34 | 112 | .30 | 2.70\* |

*a* Conditional probability of experiencing a TOT on Test 2.

The odds ratio compares the likelihood of a resolved TOT state to repeat versus an unresolved TOT state to repeat. Odds ratios are calculated from a dichotic variable of Test 2 TOT versus another Test 2 response.

\**p* < .01

**Figure 4**. The relationship between age and the conditional probability of a TOT state on Test 2 given an unresolved TOT state on Test 1.

**Note:** This distribution is clearly not linear, but for simplicity of interpretation we report linear relationships. In our analyses of Spearman’s Rho, the pattern of relationships does not appear to change.

**Figure 5.** The relationship between the number of Test 1 Unresolved TOT responses and Montreal Cognitive Assessment Scores.

**Figure 6**. The relationship between the conditional probability of repeating a TOT on Test 2 given an unresolved TOT response on Test 1 and MoCA scores.

**Chapter Four - Neither Cue Familiarity nor Semantic Cues Increase the Likelihood of Repeating a Tip-of-the-Tongue State**

Oliver L.K., Li, T., Harley, J.J. & Humphreys, K.R. (in review). Neither cue familiarity nor semantic cues increase the likelihood of repeating a tip-of-the-tongue state. *Acta Psychologica.*

 A tip-of-the-tongue (TOT) state is the phenomenon that leaves a speaker feeling like a word is on the tip of the tongue, but the word is far enough out of reach that it is inarticulable. TOT states can lead to socially embarrassing situations such as forgetting the name of a colleague or acquaintance. The TOT state has been a phenomenon of interest for both psycholinguistic and metacognitive researchers. Psycholinguists hypothesize that the TOT state serves as a phenomenon that provides direct observation as to how lexical selection occurs (e.g., Burke et al., 1991; Gollan & Brown; 2006; Harley & Bown, 1998; Meyer & Bock, 1992; Vitevitch, 2002; Warriner & Humphreys, 2008). The TOT state is viewed as the explicit consequence of a breakdown in the language production system. In contrast, metacognition researchers view the TOT state as the subjective feeling of temporary inaccessibility, placing focus on the dissociation between the subjective experience of a TOT state and word retrieval processes that occur in the speech production system (e.g., Schwartz, 2001). Although it is well-accepted that memory is an integral component of language production, there is a substantial disconnect between the fields on what constitutes a TOT state (as described in Schwartz, 2001). Current metacognitive research on TOT states stems from Tulving’s criticisms on the doctrine of concordance, which is the presumption that cognitive processes, behaviour, and experience are strongly associated (Schwartz, 1999; Schwartz; 2001; Tulving, 1989). While it is important to question the often-presumed interconnectivity between these three domains, we will argue that the TOT state may best be described as a mechanistic breakdown in the speech production system. Specifically, we argue that the breakdown occurs when there is failure to access phonology after successful lemma (semantic plus lexical) access.

**Memory and TOT States**

 Memory researchers frequently discuss the TOT state as a phenomenon that occurs at two levels: basic cognition and metacognition (as described in Schwartz and Metcalfe, 2011). The cognitive level is where memory retrieval occurs, whereas the metacognitive level is where higher-level processes occur (e.g., heuristics, inferences, mnemonic retrieval strategies). The distinguishing factor between the two levels is that the metacognitive level is driven by consciousness. Schwartz stresses that while the feeling of knowing may be driven by conscious processes, the mechanism underlying the TOT state is unconscious (Schwartz, 2001; Schwartz, 2006). He argues that when a lexical breakdown occurs, a built in unconscious mechanism processes cues and from there assesses the likelihood of recall from memory. The unconscious mechanism then determines whether or not a TOT state will occur. Although the proposed metacognitive monitor may be engaged during lexical breakdown, the monitor does not have direct access to the word production system (as described in Schwartz & Frazier, 2005). He argues that the experience of the TOT state is not necessarily synonymous with word retrieval failure; a TOT may exist even in cases where there is no phonological activation.

 In this paper we will focus on evaluating the cue familiarity hypothesis (a sub-hypothesis of the metacognitive account), which suggests that a TOT state may be caused by cues that trigger a feeling of familiarity (as described in Schwartz, 2001). If a cue is highly familiar, a TOT state should be more likely. Definitions with repetitive information are more likely to induce a TOT state than a short and concise definition (Koriat & Lieblich, 1977; Schwartz, 2001). It is argued that this accretion of cues can lead to a TOT state. In accordance with this view, the TOT state is more dependent on the cue than it is on the inaccessible target word.

 In sum, Schwartz (2001) argues that the underlying mechanism driving TOT states may trick us into intuitively thinking the TOT state is a direct consequence of a speech production failure due to the palpable feeling of the word being on the tip-of-the-tongue. While there may be some metacognitive involvement in the experience of a TOT state, metacognitive researchers are not adequately taking into account the various levels of representation in the word production system. We argue that the TOT state is primarily the product of a lexical breakdown between the lemma and phonological levels of word production.

**Lemma Based TOT State**

 From a psycholinguistic perspective, TOT states are a product of a failure in speech production rather than a general memory failure for lexical information. It is widely accepted that word retrieval occurs in two stages—semantic access followed by phonological access (e.g., Burke et al. 1991; Dell, 1986; Dell, Schwartz, Marin, Saffran, & Gagnon, 1997; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1997). When the most strongly activated conceptual information is chosen, the non-linguistic information is mapped onto the grammatical and syntactic information for the target word. The grammatical and syntactic information is then mapped onto the phonology of the word, and from there successful articulation can occur. The most dominant account for the mechanism underlying the TOT state hypothesizes that TOT states arise from weakened phonological nodes, which was originally termed as Node Structure Theory (NST; Burke, MacKay, Worthley, & Wade, 1991; MacKay, 1987; MacKay & Burke, 1990). NST states that successful articulation of the target word will occur if every phonological node for the target word is sufficiently activated. If there is insufficient activation for any single node, a TOT state will occur; phonological activation is an all-or-nothing process. NST is now more often referred to as the Transmission Deficit Hypothesis (TDH; Burke et al., 2000; Burke et al., 1991; MacKay & Burke, 1990). Burke and colleagues’ findings suggest that factors such as recency and frequency of use can have an effect on the transmission of activation to phonology.

 The term ‘lexical node’ from NST—the lexical unit containing syntactic and semantic information that has not yet been mapped onto the phonological form of the word—is now referred to as the lemma (Kempen & Huijbers, 1983). Following the emergence of the TDH, the term lemma has become more prevalent in psycholinguistics discourse. It is now widely accepted within this literature that the TOT state occurs as the result of a transmission deficit between the lemma and phonology (e.g., Gollan and Brown, 2006; Harley & Bown, 1997; Vitevitch, 2002). A lemma-to-phonology transmission failure during a TOT state is primarily evidenced by retrieval of phonological features related to the target word and cuing effects. The activation of a lemma produces the sensation of having knowledge of the word. Evidence for lemma activation comes from reported grammatical information during a TOT state. For example, native Italian speakers are better at accurately reporting the grammatical gender of the target word during a TOT state than when they do not know the word (Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997). This suggests that the lemma level is distinct from the conceptual and phonological level of word production (although all levels are interdependent). After successful lemma activation, but incomplete phonological activation, this often results in partial phonological information access (Beeson, Holland & Murray, 1997; Brown, 1991). Despite being unable to recall the target word, features like first letter, number of syllables, and related words are often reported (Brown & McNeill, 1966).

Presenting phonological cues facilitates TOT resolution, whereas semantic cues fail to do so, suggesting that there is activation of the lemma, but insufficient activation of phonology (Brennen, Baguley, Bright & Bruce, 1990; D’Angelo & Humphreys, 2015; Meyer & Bock, 1992). If TOT states are the product of general memory failure, both semantic and phonological cues should be likely to help facilitate resolution, but this is not the case. Rather, the phonological cue is hypothesized to strengthen the phonological form of the word, thus allowing the as-yet unaccessed stage to be accessed. Meyer and Bock (1992) explain that semantic cues may not facilitate self-resolution of a TOT state since a definition already provides a sufficient amount of semantic information; additional semantic cues are not helpful in this case. They further explain that the phonological cue may be more closely related to the target word than a semantic cue. In reference to the two-stage model of word production, a semantic cue would strengthen connections in the first stage of production, but a phonological cue would strengthen the lemma-to-phonology connections (second stage) where the TOT is argued to occur.

**Repeated TOT States**

 A more recent finding is the repetition effect—the tendency for TOT states to repeat for particular words at a rate greater than can be predicted by chance—which suggests that speakers may learn the incorrect lemma-to-phonology mappings (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). This effect occurs at immediate retest, a 48 hour delay, and a one week delay, and occurs despite verifying the correct target at the end of each trial during an initial test. Humphreys and colleagues argue that because there may only be partial or incorrect activation of phonemes during a TOT state, the speaker may be learning the erroneous lemma-to-phonology mappings, so that when that same word is encountered in the future, the strengthened erroneous mappings are more likely to be selected during word retrieval. They argue that this error repetition effect is best interpreted as an error learning effect, where a Hebbian-type learning mechanism is strengthening that incorrect lemma-to-phonology mapping. The critical question in this work is whether repeated errors are in fact due to the learning of that particular error, or whether it is simply due to idiosyncratic difficulty with a particular word. This issue has been addressed in several ways. Evidence for the error learning effect comes from a timing manipulation effect and a TOT resolution effect (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Humphreys and colleagues have found that the amount of error repetition observed can be manipulated by varying the interval of time randomly given to think about a particular target word aloud during a TOT state. Warriner and Humphreys (2008) found that those who were given more time to think about the answer (30s) had a greater tendency to repeat their TOT states than those who were only given a short interval of time (10s) to think about the answer. This means that they did not try to manipulate the likelihood of entering a TOT state on the first test, but rather they manipulated the amount of potential learning that could occur after the participant entered a TOT on the first test. It is the amount of learning that occurred during the interval of time to think about the target word aloud on the first test that determined whether or not a TOT response occurred on retest. D’Angelo and Humphreys (2015) were initially inconsistent in their ability to replicate the timing manipulation effect, but they found that the effect was dependent on whether or not the experimenter was actively encouraging the participant to speak aloud about the target word during a TOT state. Active encouragement to speak aloud may drive participants to think harder about the target word, leading to strengthening of the erroneous lemma-to-phonology pathway, and therefore increasing error learning.

 TOT states are also less likely to repeat for a particular word on retest if the TOT state was self-resolved on the first test. This is referred to as the resolution effect. Humphreys and colleagues argue that although erroneous lemma-to-phonology mappings can be learned, these erroneous connections can also be unlearned. If a speaker conducts a successful search for the target word during a TOT state, the TOT state may be unlearned by creating a new and correct pathway to the target word, and thereby relatively weakening the old and incorrect one. A successful search for the target word may occur when there is sufficient access to correct lexical and phonological features (e.g., the first letter of the word) that collectively produce enough activation to push one past the threshold for activation of the entire correct phonological form. Through procedural learning, the speaker has now reinforced the correct pathway, which is stored in the word production system. Upon encountering the word in future, the speaker should be less likely to enter into a TOT state. In an unsuccessful word search, although the speaker may have access to some lexical or phonological information, there may not be enough cumulative activation to reach threshold for full phonological activation of the target word. Consequently, the word production system may now store this erroneous retrieval pathway for a particular target word. Critically, the resolution effect is observed even when the speaker does not self-resolve the word, but is given a phonological cue that enables them to resolve the word (D’Angelo & Humphreys, 2015). This finding argues strongly against the explanation that pre-existing individual difficulty on particular target words is driving the error learning effect. If a specific target word is difficult for a speaker, providing a phonological cue should not be particularly helpful in facilitating resolution on the first test, but critically, the speaker should not be more likely to produce the target word on retest given that the TOT state was resolved after phonological cuing on the first test. Rather, the phonological cue may facilitate resolution on Test 1 by giving the speaker a boost to reach the threshold of phonological activation, and thereby reinforcing the correct pathway, so that when the target word is encountered again on retest, a TOT state is less likely to occur.

**Repeated TOT States and Cue Familiarity**

 The error repetition effect could plausibly be driven by cue familiarity. As previously mentioned, the cue familiarity hypothesis suggests that the TOT state is dependent on the familiarity of a cue rather than the retrieval processes (Koriat & Lieblich, 1977; Metcalfe et al., 1993; Schwartz, 2001). Metcalfe et al. (1993) investigated this hypothesis by having participants study target words that were paired with a cue. They found that when both the cue and target were repeated during the study phase (A-B, A-B), this condition resulted in both better cued recall and a high number of TOTs for target words. When the cue was repeated, but the target was not (A-B, A-D), this resulted in low recall, but a high number of TOT states. The critical finding is that similar to the A-B, A-B condition, the A-B, A-D condition also resulted in a large proportion of TOT states as compared to a condition in which neither the cue or target word was repeated (A-B, C-D). Due to the high number of TOT states, but low recall in the A-B, A-D condition, Metcalfe et al. argue that the TOT states were due to the familiarity of the cues considering it appears that participants did not actually know the word, as evidenced by failed cued recall. In the repeated TOT paradigm by Humphreys and colleagues, identical definitions are used on test and retest. From a metacognitive standpoint, the definition used to elicit a TOT state on the first test is functioning as a cue on retest. Due to the definition having already been presented on Test 1, the familiarity of the cue on Test 2 may be driving the participant to report a TOT state, leading to the illusion of learned TOT states. In other cases, if more than one semantic cue is presented to a speaker, this increased number of cues could lead to an increase in familiarity, and therefore leading one to repeat a TOT state on Test 2.

**Current Study**

 To give a brief overview, we conducted two experiments that primarily examine the metacognitive cue familiarity hypothesis, and we also conducted a third additional experiment that primarily assesses the role of semantics in TOT elicitation, but is also relevant to the cue familiarity hypothesis. All three experiments use the Warriner and Humphreys (2008) repeated TOT procedure. Participants are presented with a prompt whether it is a definition, a picture of a famous person, or a description of a famous person. Participants are asked to verbally produce the word or name that accompanies the prompt (and to report if they do not know or are experiencing a TOT state for the word). Participants are then retested at a later time with either an identical, or an alternative cue for the same target. In accordance with the Metcalfe et al. (1993) study, identical prompts (i.e., cues) across test and retest should lead to a higher likelihood of a repeated TOT state. From a metacognitive perspective, seeing two identical prompts would make a repeated TOT most likely, as the memory of that prompt would also now be associated with the metamemory of the previous retrieval failure, giving the participant the subjective experience of that same cognitive state. Similarly, providing an alternative cue at Test 2 might put a participant in a different enough state from their Test 1 TOT response that they are more inclined to report not knowing the word (due to a lack of familiarity with the new alternative cue), rather than being in a TOT state for the second time. This metacognitive account would predict fewer repeated TOT states when given an alternative prompt at Test 2.

 However, given that we predict that cue familiarity does not primarily give rise to repeated TOT states, our first hypothesis was that the error repetition effect would be observed in both the identical and alternative prompt conditions, and critically, that the likelihood of repeating a TOT state would not significantly differ between the conditions. If providing identical prompts (i.e., cues) does not increase the likelihood of a repeated TOT, we argue that TOT states do not arise due to cue familiarity.

 If our first hypothesis is correct, which is that we find there is no difference between the identical and alternative prompt conditions in the tendency for TOT states to repeat, there is a strong alternative explanation for this finding. We would argue that no difference between the conditions means that the results point toward a lemma-to-phonological failure account of TOT states, considering this finding would provide evidence that rules out a cue familiarity mechanism. However, there could be an alternative explanation. It is possible that a description and a picture have semantic overlap, and therefore one could predict that the probability of repeating a TOT state would not be different between the identical and alternative conditions. In other words, the alternative cues are providing the same type of semantic information; our cues may not be different enough to demonstrate differences between the conditions. However, we argue that the presentation of semantic information (and the amount of semantic information presented) is irrelevant if one is in a TOT state.

 Therefore, our second hypothesis was that presenting more than one semantic cue would not increase the probability of repeating a TOT state. Considering the word production system, presenting semantic cues (which should help activate a concept-level representation, and drive concept-to-lemma activation) should not increase the probability of repeating a TOT state, since the locus of the TOT state is argued to be between the lemma representation and subsequent activation of phonology. Conversely, from a cue-familiarity hypothesis standpoint, presenting more than one semantic cue on Test 1 should induce more repeated TOT states than if only one semantic cue is presented. For instance, Koriat and Lieblich (1977) found that redundant information leads to a stronger feeling of knowing. Therefore, the additional cue should arouse a more salient sense of familiarity, leading to more repeated TOT states.

 In experiment one, definitions of words are presented to participants at the first test, but with the change that either an identical or an alternative definition of the same word is used at retest. We note that an alternative definition may not differ enough from the original definition to be a significantly different memory cue, so we addressed this problem in Experiment 2. Participants were presented with very different (i.e., alternative) memory cues (faces and descriptions of actors, with the goal of retrieving their names). If there is no difference in the likelihood of a repeated TOT on Test 2, we argue that this is further evidence to rule out the cue familiarity hypothesis. We further note that there may be a significant amount of semantic overlap between alternative cues. In experiment three, we presented either a picture and description or a description only on Test 1, followed by a description only on Test 2. If there is no difference between the one-cue and two-cue condition, we argue that this finding is evidence against the cue familiarity hypothesis in the sense that the semantic level of word production is not directly relevant to TOT states.

**Experiment 1**

 Experiment 1 examined what occurs when participants are given alternative definitions of words given at Test 1 and Test 2. We hypothesized that if the locus of the TOT (and TOT learning effect) is in the lemma-to-phonology mapping, altering the definitions should have no effect on the likelihood of TOT repetition. However, if cue familiarity is driving the rates of reported TOTs, altered definitions on Time 2 should decrease the number of repeated TOT states.

**Methods**

**Participants**

 Participants included 52 McMaster University undergraduate students (31 females, 21 males) with a mean age of 18.5. All participants were native English speakers. Participants were compensated for their time with course credit. This protocol received ethics approval from the McMaster Research Ethics Board.

**Materials**

**Experimental Measures**

 The stimuli were presented using Presentation experimental software (v16.5, www.neurobs.com), which was also used to record all keyboard responses made by participants. Participants were tested individually, seated at a desk facing a standard 19” CRT monitor and in comfortable reach of a keyboard that was specially marked. Three letter keys were labeled as response buttons (KNOW, TOT, DON’T KNOW). Two number pad keys were labeled (YES and NO). Verbal responses were recorded from a head-worn Shure microphone onto CDs using a CDR300 Marantz Professional recorder.

 The set of target words consisted of 44 words from the stimuli used by Warriner and Humphreys (2008). There were two lists of definition prompts (see Appendix 1 for stimuli). Each target word was paired with a corresponding definition prompt identical to the prompt used by Warriner and Humphreys (2008), as well as a rephrased (alternative) definition prompt. The rephrased definition prompts were created for this experiment by citing alternative definitions for the target words from WordNet database (http://wordnet.princeton.edu). In total, there was a list of 44 definition prompts from Warriner and Humphreys (2008) and a list of 44 rephrased definition prompts from WordNet. Four counterbalanced lists were created, where the factors of Test 1 definition (original vs. rephrased) and Test 2 definition repetition (identical vs. alternative) were manipulated both within subject and within item. The order of target words was different between Test 1 and Test 2. Whether the original vs. rephrased definition was used at Test 1 was only intended as a counterbalancing factor, our intent was to make both versions of the definition equally good as a prompt.

**Procedure**

 **TOT task 1.** Participants were seated at a desk facing the computer monitor while in reach of a specially marked keyboard. The experiment began with written instructions on how to decide which button (KNOW, TOT, DON’T KNOW) corresponded to their current state of knowing. Participants were told to select the KNOW button if they knew the correct response to the definition prompt. Participants were told to select TOT if they were certain that they knew the word despite being unable to say it out loud. They were told that additional indications of being in this state were described as including the ability to reject synonyms or knowing partial information about the word, such as the first letter or number of syllables. Participants were instructed to press the DON’T KNOW button in all other cases ranging from a complete lack of recognition, to a vague sense of familiarity without the concrete sense of knowing (feeling of knowing).

 Each trial began with the presentation of a definition prompt in the center of the screen. Participants were instructed to read the prompt and immediately select the response button that most accurately reflected their state of knowing concerning the target word. On Test 1, participants who pressed either the DON’T KNOW or TOT button on a given trial were allotted a 15-second period to think about the answer out loud. If at any time the participant decided that they knew the answer, they were instructed to press the KNOW button. Pressing the KNOW button at any time advanced participants to a screen that prompted them to say the answer aloud. If the allotted time expired before participants arrived at a response, the participants were automatically forwarded to this same screen. If participants had successfully recalled a word, they were prompted to say the answer aloud. If participants did not have an answer, they were told to say so. Participants were prompted to press YES or NO to indicate whether the answer is the word they were thinking of.

 **TOT task 2**. Participants were given a five-minute break before beginning Test 2. The procedure for Test 2 was identical to that of Test 1. However, at retest, participants were not given any time to resolve TOTs or DON’T KNOWs before being told the correct answer.

**Results and Discussion**

 In this paradigm it is critical to ascertain whether participants were in fact thinking of the intended target word in their TOT state, otherwise we cannot reliably tell whether the same error state is being repeated. Therefore our analyses only include what we have called valid responses. Of the total 2,288 Test 1/Test 2 pairs, 636 invalid trials were excluded. There were several criteria by which a response could be considered invalid, including instances when the participant initially reported knowing the word but later indicated that their answer was not the word they were thinking of. Responses in which the participant reported a TOT but indicated that the correct answer was not the word they were thinking of were also excluded. Exclusion of invalid trials eliminated instances of feeling of knowing from a true TOT state. It is plausible that participants may have been experiencing a true TOT state, but not on the expected target word. The number of invalid response pairs per participant ranged from 5% to 45% with a mean of 16%, indicating that mistakes were a common experience. This also gives us confidence that participants understood what was meant by a TOT and were responding honestly. Fifty-one out of fifty-two participants experienced at least one TOT response, so we can conclude that all but one participant contributed to the TOT responses.

 Table 6 on page 91 summarizes response data as a contingency table, collapsed across participants. The conditional probabilities in Table 1 represent the Know, Don’t Know, and TOT responses on Test 2 given a Know, Don’t Know, or TOT response on Test 1. Our analyses further distinguish TOT and DON’T KNOW responses as either resolved or unresolved. Resolved TOT or DON’T KNOW responses were instances where speakers initially reported TOT or DON’T KNOW, but remembered the target word during the interval of time given to think aloud, and reported the correct word before the correct word was revealed. In contrast, an unresolved TOT or DON’T KNOW response was an instance where the speaker did not remember and report the target word before the target word was revealed. We collapse over whether the definitions used were the original definitions or not. Table 6 also reports the conditional probabilities for all types of Test 2 responses (KNOW, DON’T KNOW, TOT) as a function of Test 1 responses, collapsed over all participants. The critical comparison for our purposes is between the identical prompts condition and the alternative prompts condition

 In the identical prompts condition, the probability of a TOT response on Test 2 given an unresolved TOT response on Test 1 was 0.21. The probability of a TOT on Test 2 given an unresolved DON’T KNOW response on Test 1 was 0.13. The probability of a TOT on Test 2 given a KNOW response on Test 1 was 0.01. On Test 1, 16.1% of responses were TOTs. On Test 2, 9.7% of responses were TOTs. In summary, those who reported a TOT on Test 1 were relatively more likely to report TOT, rather than KNOW or DON’T KNOW, on Test 2.

 In the alternative prompts condition, the probability of a TOT response on Test 2 given an unresolved TOT response on Test 1 was nearly the same as in the identical prompts condition: 0.20. The probability of a TOT on Test 2 given an unresolved DON’T KNOW response on Test 1 was 0.13. The probability of a TOT on Test 2 given a KNOW response on Test 1 was 0.03. On Test 1, 15.8% of all responses were TOTs. On Test 2, 8.5% of all responses were TOTs. In summary, speakers who reported a TOT on Test 1 were relatively more likely to report TOT, rather than KNOW or DON’T KNOW, on Test 2.

 The odds ratio (OR) for repeated TOTs is the odds of experiencing a TOT on Test 2 versus another response given a TOT or a non-TOT response for that item on Test 1. If the odds ratio is equal to 1, this means that experiencing a TOT on Test 1 does not make a speaker any more likely to re-experience a TOT for that word on Test 2. From the log of the odds ratio, we calculated a 95% confidence interval of the odds ratio to test whether the odds ratio is significantly greater than 1. In addition, we calculated a Z-score and a corresponding p value to describe differences in the conditional probabilities. The Z score was calculated by dividing the log odds ratio by the standard error of the log odds ratio. For the sake of clarity, we report the odds ratios in Table 6, as they are more intuitive than the log odds ratios, but significance was assessed based on the corresponding log odds ratios.

The OR for Test 2 TOTs as a function of Test 1 TOT versus non-TOT responses when the definition was identical on Test 1 and Test 2 was 2.62, with lower and upper limits of the 95% CI of 1.48 and 4.63 (*z* = 3.33, *p* < .001). This means the odds of experiencing a TOT on Test 2 is over twice as likely if one experienced a TOT on Test 1 as compared to all other responses (Know and Don’t Know). The OR for Test 2 TOTs as a function of Test 1 TOT versus non-TOT responses when there were alternative definitions between Test 1 and Test 2 was 1.81, with lower and upper limits of the 95% CI of 0.99 and 3.29 (*z* = 1.93, *p* = 0.05). We note that although the conditional probabilities of a repeated TOT are 0.21 for identical and .20 for alternative prompts, the ORs are different. The odds ratio is sensitive to slightly different underlying total number of responses in a way that a conditional probability is not.

Overall, TOTs are as likely to repeat following an identical as an alternative prompt, which aligns with our hypothesis that providing alternative cues would not change the likelihood of repeating a TOT state. The results demonstrate that the identical cues were not driving a cue familiarity effect (recall that the likelihood of repeating a TOT should have been higher in the identical condition). We do note that there is a numerical tendency for speakers to respond DON’T KNOW more often after an alternative prompt (conditional probability of 0.02 for identical prompts and 0.11 for alternative prompts when the TOT was resolved on Test 1, which was based on very small numbers, and is non-significant). There is also no evidence that a TOT at Test 1 is more likely to become a KNOW at Test 2 when given an alternative prompt (0.66 and 0.72 for alternative and identical prompts respectively).

**Experiment 2**

In Experiment 1, it is possible that the rephrased (alternative) definitions may not have differed enough to observe a significant difference between repeating TOT states in the identical versus alternative prompts condition. It is also possible that a rephrased definition on retest triggers a feeling of familiarity due to the highly similar content between definitions. We addressed this issue in Experiment 2 by using very different (alternative) cues. Instead of rephrased definitions, we used different modalities of prompts (descriptions versus pictures of famous individuals).Again, we hypothesized that if the locus of the TOT (and TOT learning effect) is in the lemma-to-phonology mapping, even altering the modalities should have no effect on the likelihood of TOT repetition.

**Methods**

**Participants**

 Forty native-English speaking undergraduates (32 females, 8 males) from McMaster University participated in the experiment for introductory psychology course credit. The mean age was 19.6 years. This experiment received ethics approval from the McMaster University Ethics Board.

**Materials**

**Experimental Measures**

 Sixty colour, forward-facing photographs of famous actors and actresses were collected from the Internet Movie Database (http://www.imdb.com/). The actors and actresses were selected for their familiarity to the age group of our participants, as determined by informal piloting. All actors and actresses had two-word names (first and last name [e.g., Matt Damon]). Descriptions were generated from their recognizable roles and movies, also from the Internet Movie Database (e.g., "He played Jason Bourne in The Bourne Identity" [Matt Damon]).

**Procedure**

 Each participant saw all 60 items, randomly ordered and assigned into four conditions, based on whether faces or descriptions were presented in Test 1 and Test 2 (FACE-FACE, FACE-DESCRIPTION, DESCRIPTION-FACE, DESCRIPTION-DESCRIPTION). Four counterbalanced lists were generated with presentation condition as a within item and within participant variable. The lists were presented in a random order for each participant. Aside from the difference in stimuli, the same procedure was followed as in Experiment 1.

**Results and Discussion**

Invalid trials were excluded on the same basis as in experiment one. Self-resolved trials were trials in which participants reported being in a TOT state, but were able to retrieve the correct name within the 15-second delay. Unresolved trials were trials in which participants reported being a TOT state, but were unable to retrieve the correct name within the delay. Of the 2400 trial pairs, 528 (22%) had invalid responses on either test, leaving 1872 valid trial pairs (78%). Thirty-six out of forty participants experienced at least one TOT.

 Table 7 on page 92 summarizes the responses, collapsed across participants, with the four conditions grouped into two, alternative-retest modality (FACE-DESCRIPTION, DESCRIPTION-FACE) and identical test-retest modality (FACE-FACE, DESCRIPTION-DESCRIPTION). The conditional probability of repeated unresolved TOTs is greater than all other possible Test 1 responses for both different modality (0.17) and same modality (0.23) conditions. Both the identical and alternative modality conditions demonstrated a statistically significant error repetition effect. The OR comparing TOT and non-TOT responses on Test 1 with those on Test 2 for the alternative prompt modality conditions show participants were over four times more likely to re-experience a TOT after a TOT on Test 1 than a non-TOT (OR = 4.68, 95%CI [2.22-9.86], *z* = 4.06, *p* < 0.001). Conversely, for the identical prompt modality conditions, participants were over eight times more likely to re-experience a TOT after a TOT on Test 1 than a non-TOT (OR = 8.99, 95% CI [4.06-19.88], *z* = 5.42, *p* < 0.001). Taking the difference score of the odds ratios for the alternative and identical modality conditions and determining the z-score and p-value showed that there is no statistically significant difference between them (*z* = 1.17, *p* > 0.05). In addition to the error repetition effect, a resolution effect was also observed in the comparison of alternative and identical modality conditions. However, only the resolution effect of the identical modality conditions was statistically significant (OR = 3.70, 95% CI [1.02-13.43], *z* = 1.99, *p* < 0.05).

 Overall, our data show that TOT errors tend to repeat, regardless of whether the prompts are identical or not, and that there is no statistical difference in the likelihood of repeating a TOT state between the identical and alternative prompts condition, even when the alternative prompts are very different in nature. This is consistent with a model in which a TOT state has fully selected/recalled semantic information, but is only missing phonological information, and is not well predicted by a cue-familiarity hypothesis. For an even stronger test of the role of amount of semantic information in TOTs, we varied this explicitly in Experiment 3.

**Experiment 3**

 Recall that it is widely agreed upon that there are two stages of word production (e.g., Dell, 1986, Levelt et al., 1999). The first is the conceptual-to-lemma stage, followed by the lemma-to-phonology stage. It is widely hypothesized that TOT states occur when there is a breakdown between the lemma (i.e., lexical) and phonological (i.e., sound) levels of word production. Specifically, there is full lemma access, but only partial phonological access. Access to conceptual/semantic information precedes lemma and phonological access. Considering that there is theoretically full lemma access during a TOT state, this means that there is already full semantic access. In Experiment 3, we presented participants with either one semantic cue or two semantic cues to elicit TOT states, followed by a retest with only one of the semantic cues.

 Considering a cue-familiarity mechanism, presenting more than one semantic cue provides more information at encoding, and therefore at retest should induce a stronger state of familiarity than one semantic cue at encoding. This heightened feeling of familiarity would then be predicted to lead to repeated TOT responses. Therefore a metacognitive hypothesis would suggest that the likelihood of repeating a TOT state should be greater when a speaker is presented with two semantic cues instead of one semantic cue upon initial encoding. In line with this hypothesis is the finding that redundant information leads to a stronger feeling of knowing (Koriat and Lieblich, 1977). However, from the psycholinguistic point of view, we argue that the number of semantic cues (or type) should be irrelevant to the repetition effect. If one is already in a TOT state, there is full lemma access, so presenting extra semantic information will have a minimal effect on repeated TOT states. Therefore, we hypothesized that the likelihood of repeating a TOT state would remain the same between conditions (one semantic cue versus two semantic cues). While this experiment does not directly address the phonological failure account of TOT states, if we find evidence that rules out the possibility that semantic representation is a primary source of TOT states, these findings would point towards a lemma-to-phonological failure account of TOT states.

**Methods**

**Participants**

 Thirty-eight native-English speaking undergraduates (28 females, 9 males, 1 unspecified) from McMaster University participated in the experiment for introductory psychology course credit. The mean age of participants was 20.6 years. This experiment received ethics approval from the McMaster University Ethics Board.

**Materials**

**Experimental Measures**

 The same photographs and descriptions of famous actors and actresses from Experiment 2 were used in this experiment.

**Procedure**

 Each participant saw all 60 items, randomly ordered in both Test 1 and Test 2. In Test 1, participants were prompted with a description and the corresponding photo simultaneously (DESCRIPTION+FACE) for half the trials and just a description (DESCRIPTION ONLY) for the other half. The condition of the stimuli presentation (DESCRIPTION+FACE vs DESCRIPTION ONLY) was randomly assigned for each participant. In Test 2, participants were prompted with a description only for all items. The same procedure was followed as in the two previous experiments.

**Results and Discussion**

Invalid trials were excluded on the same basis as in the previous two experiments. Of the 2280 trial pairs, 337 (15%) had invalid responses on either test, leaving 1943 valid trial pairs (85%). Thirty-five out of thirty-eight participants experienced at least one TOT.

 Table 8 on page 93 summarizes the responses, collapsed across participants, for the two conditions (DESCRIPTION+FACE and DESCRIPTION ONLY). The conditional probability of repeated unresolved TOTs is greater than all other possible Test 1 responses for both presentation of the description and face prompts (0.25) and the descriptions only (0.25). The error repetition effect was statistically significant for both conditions. The OR comparing TOT and non-TOT responses on Test 1 with those on Test 2 for when a description and face were shown on Test 1 show participants were over six times more likely to re-experience a TOT after a TOT on Test 1 than a non-TOT (OR = 6.84, 95%CI [4.00-11.69], *z* = 7.03, *p* < 0.001). In the description only condition, participants were over five times more likely to re-experience a TOT after a TOT on Test 1 than a non-TOT (OR = 5.91, 95% CI [3.48-10.04], *z* = 6.56, *p* < 0.001).

 Critically, the value of the conditional probability of repeating a TOT state (0.25) is identical for the DESCRIPTION+FACE and DESCRIPTION ONLY conditions. Taking the difference score of the two odds ratios (note these are slightly different than the conditional probabilities due to the dichotomizing of the ORs) and determining the z-score and p-value showed that there is no statistically significant difference between them (*z* = 0.38, *p* > 0.05). Participants were equally likely to experience a repeated unresolved TOT when prompted with a description only at time 2, regardless of being shown a description and face, or a description only, at time 1. This is strong evidence for a lemma-to-phonology failure account of TOT state etiology.

 As mentioned, there is already full access to the lemma during a TOT state. Therefore, providing an additional semantic cue was not enough to induce a higher likelihood of repeated TOT states than providing only one cue. If the cue-familiarity hypothesis were driving the error repetition effect (i.e., TOT repetition), then adding an additional cue should have triggered a stronger feeling of familiarity than only one cue, and this increase in familiarity (or feeling that the word is immanently recallable) would have given rise to more repeated TOT states. However, this was not the case. Furthermore, the results demonstrate that semantic-level representation is not the locus of the error repetition effect (i.e., repeated TOT states). If the first stage of word production (conceptual-to-lemma connections) was lacking activation, then presenting two semantic cues versus one semantic cue should have pushed participants from a ‘Don’t Know’ state to a TOT state, leading to more repeated TOT states. Yet, the extra semantic cue did not increase the likelihood of repeating a TOT state. The results support our hypothesis in that the likelihood of repeating a TOT state was identical regardless of participants being given one semantic cue or two semantic cues.

 The Test 1 TOT rate for description only (one cue condition) was 13% versus 16% for the description and picture (two cue condition). We do acknowledge the slight increase in Test 1 TOT states for the description and picture description, and that there could have been some instances where an additional semantic cue induced a feeling of knowing. However, clearly these cases are very few so it is quite possible that the slight increases in TOT states is due to random noise. If this small increase were due to a cue-familiarity mechanism, then we would have found a greater tendency for TOT states to repeat in the description and picture condition, but this was not the case.

**General Discussion**

**Central Findings**

 The primary finding across the three experiments is that the error repetition effect—the tendency for TOTs to repeat at rate greater than can be predicted by chance—does not differ between identical prompts (as used in the original TOT paradigm), alternative prompts, or presenting one or more than one prompt on Test 1. In other words, whether participants are given the same definitions or different definitions on test and retest, the nature and size of the error repetition effect remains the same. Furthermore, when we manipulated the degree of differentness in the cues in Experiment 2 (pictures versus description), there was still no difference in the likelihood of repeating a TOT state between identical and alternative prompt conditions. In addition, when we used two initial prompts (a picture and description) versus one prompt (a description), there was still no difference between the two conditions in repeating a TOT state, despite the greater amount of information provided at encoding by the double prompt.

We argue that these findings are not well explained by cue familiarity. If TOT states are primarily the product of a metacognitive mechanism, we should have observed that participants who are given identical cues across test and retest are more likely to experience a repeated TOT state. We should have also found that presenting more than one cue on Test 1 would have resulted in a higher likelihood of repeating a TOT state due to the accretion of familiarity. If reporting a TOT is increased in likelihood by a metamemory-type feeling of knowing a word, the greater amount of information provided at encoding for the double prompt should have led to a higher likelihood of TOTs on retest. Instead, our data show that all these differences in degree and kind of semantic information that are typically thought to lead to differences in cue familiarity have no influence on repeated TOT likelihood.

**Interpretation of Results**

 The results suggest that the TOT state is lexically-dependent rather than cue-dependent (or familiarity dependent). Regardless of the prompts given across test and retest (identical definitions, alternative definitions, descriptions of famous people, pictures of famous people, or alternative stimulus modalities for famous people), the tendency for TOT states to repeat remains the same. These findings suggest that the prompt used to experimentally elicit a TOT state plays a minimal role in repeated TOT states. According to the psycholinguistic account, alternative prompts for the same target word should theoretically activate the same lexical information and therefore often times lead to the same response across test and retest. If one is in a TOT state, there is already access to semantic information, and therefore there is enough activation to successfully access the lemma. Alternative semantic cues are unhelpful due to the earlier conceptual stage of word production already being successfully activated. The metacognitive account does not have a specific theoretical explanation for the various levels of word production/recall involved, and how semantic information appears to be privileged in a TOT state relative to phonological information. From a metacognitive standpoint, any additional information, whether semantic or phonological, may be helpful. It is more plausible that TOT responses are the result of whether or not the target word is stored in the lexicon, and how strongly that word is represented. If there is sufficient activation of the full phonological form of the target word after successful lemma access, the speaker should report a Know response. Successful lemma access followed by partial phonological access, should result in a TOT response. Lastly, if there is insufficient conceptual or lemma access, a Don’t Know response is most likely to occur.

 The repetition of TOT states regardless of prompt condition shows it is likely that there is an alternative underlying mechanism driving the repeated error. Since repeated TOT states do not appear to be cue dependent, it is unlikely that participants are learning to associate the prompt (i.e., cue) with the feeling that accompanies a TOT state between test and retest. As previously mentioned, Humphreys and colleagues have shown through both timing manipulations and the resolution effect that repeated TOT states are not solely due to item specific difficulty. They argue that TOT states are due to learned erroneous mappings between the lemma and phonological level of word production, which is an argument built upon the widely accepted hypothesis that the TOT state is a product of successful lemma activation, followed by insufficient phonological activation (e.g., Gollan & Brown, 2006). Therefore, if repeated TOT states are not driven by cue familiarity as we found in this paper or item specific difficulty (see D’Angelo & Humphreys (2015) and Warriner & Humphreys (2008)), we argue that TOT states are repeating due to learned lemma-to-phonology mappings (i.e., the error learning effect).

 While all three experiments provide evidence that rules out a cue-familiarity hypothesis of TOT states, the third experiment is an even more direct test of whether or not the semantic level of word production is directly implicated in TOT states. Rather than directly test the lemma-phonological component of TOT states, we decided to instead examine the role of semantics in TOT state etiology considering that semantics are not often the primary point of interest in psycholinguistic studies that examine TOT states. Providing extra semantic information did not induce a higher likelihood of repeated TOT states. Metacognitively, the extra semantic cue should have given rise to a strong feeling of familiarity, leading one to report a repeated TOT. However, additional semantic information on both the first test and retest did not improve performance, consistent with the idea that the semantic representation is already adequately accessed during a TOT state, but that phonology has not yet been fully accessed. Therefore, we argue that this result points toward a breakdown between the lemma and phonological stage of word production.

**Conclusions**

 Although we do acknowledge that there is more work to be done on the metacognitive versus psycholinguistic view of TOT states, our results are in favour of the psycholinguistic account of the mechanism underlying the TOT state. Specifically, that there is a lexical breakdown between the lemma and phonology. We do agree that the TOT state is in a metacognitive sense a particularly odd event, where it at least feels like there is some unusual awareness into one’s internal cognitive state, similar to phenomenological experiences like déjà vu. The psycholinguistic account of TOT states has not significantly added to a theory of why this is the case and should be explored in future research. We also acknowledge that the cue-familiarity hypothesis is only one hypothesis within the metacognitive account. However the cue-familiarity account of TOT states is a prominent account within the field of metacognition and the work outlined in this paper presents strong theoretical arguments that the TOT state is not cue-dependent, and behaves fairly differently from typical recall phenomena.

 The crux of the problem lies within whether or not there is direct partial phonological access during a TOT state; psycholinguists often cite reported phonological information during a TOT state as evidence for direct phonological access, while metacognition researchers argue against it. The metacognition field is lacking a developed theoretical account for the evidence of both successful lemma access plus partial phonological access during a TOT state. Both fields can learn from one another, but taking into account the evidence from both sides in tandem with the findings in this paper, the evidence leans toward a psycholinguistic account of the TOT state.

Table 6

*Cross-Tabulation of Test 1 and Test 2 Responses*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | Test 2 Responses |  |  |
| Condition | Test 1 Response |  | Know | Don’t Know | TOT | Total | Conditional Probability of TOT*ᵅ* |
| Identical Prompts |  |  |  |  |  |  |  |
|  | Know |  | 377 (.99) | 1 (0) | 4 | 382 | .01 |
|  | Don’t Know | Unresolved | 146 (.50) | 110 (.37) | 38 | 294 | .13 |
|  |  | Resolved | 17 (1.0) | 0 (.00) | 0 | 17 | 0 |
|  | TOT | Unresolved | 59 (.72) | 6 (.07) | 17 | 82 | .21\* |
|  |  | Resolved | 52 (.93) | 1 (.02) | 3 | 56 | .05 |
|  | Total |  | 651 | 118 | 62 | 831 |  |
| Alternative Prompts |  |  |  |  |  |  |  |
|  | Know |  | 360 (.93) | 15 (0.04) | 10 | 385 | .03 |
|  | Don't Know | Unresolved | 143 (.51) | 103 (.36) | 37 | 283 | .13 |
|  |  | Resolved | 17 (.90) | 1 (.05) | 1 | 19 | .05 |
|  | TOT | Unresolved | 49 (.66) | 10 (.14) | 15 | 74 | .20 |
|  |  | Resolved | 52 (.80) | 7 (.11) | 6 | 65 | .09 |
|  | Total |  | 621 | 136 | 69 | 826 |  |

*ᵅ* Conditional probability of experiencing a TOT on the second test.

*b* Numbers in parentheses indicate the conditional probability of that response at Test 2, given the corresponding response at Test 1. For TOTs, being our crucial measurement, this number is presented in its own column.

\**p* < 0.05, according to OR calculations in text.

Table 7

*Cross-Tabulation of Test 1 and Test 2 Responses*

|  |  |  |  |
| --- | --- | --- | --- |
| Condition | Test 1 Response | Test 2 Responses | Conditional Probability of TOT*ᵅ* |
| Know | Don't Know | TOT | Totals |
| Identical Modality | Know |  | 261 (.98) | 2 (.01) | 3 | 266 | .01 |
| Don’t Know | Unresolved | 69 (.12) | 517 (.86) | 12 | 598 | .02 |
| Resolved | 8 (.50) | 8 (.50) |  | 16 | 0 |
| TOT | Unresolved | 24 (.69) | 3 (.08) | 8 | 35 | .23\* |
| Resolved | 49 (.91) | 1 (.02) | 4 | 54 | .07 |
| Totals |  | 411 | 531 | 27 | 969 |  |
| Alternative Modality | Know |  | 195 (.84) | 27 (.12) | 9  | 231 | .04 |
| Don't Know | Unresolved | 85 (.15) | 453 (.83) | 11 | 549 | .02 |
| Resolved | 6 (.5) | 6 (.5) |  | 12 | 0 |
| TOT | Unresolved | 24 (.57) | 11 (.26) | 7 | 42 | .17\* |
| Resolved | 51 (.74) | 13 (.19) | 5  | 69 | .07 |
| Totals |  | 361 | 510 | 32 | 903 |  |

*ᵅ* Conditional probability of experiencing a TOT on the second test.

\**p* < 0.05 according to OR calculations in text.

Table 8

*Cross-Tabulation of Test 1 and Test 2 Responses*

|  |  |  |  |
| --- | --- | --- | --- |
| Condition | Test 1 Response | Test 2 Responses | Conditional Probability of TOT*ᵅ* |
| Know | Don't Know | TOT | Totals |
| Description and Photo Shown at Time 1 (DESCRIPTION+FACE) | Know |  | 207 (0.81) | 42 (0.16) | 7 | 256 | 0.03 |
| Don’t Know | Unresolved | 28 (0.05) | 505 (0.91) | 22 | 555 | 0.04 |
| Resolved | 3 (0.6) | 2 (0.40) | 0 | 5 | 0 |
| TOT | Unresolved | 44 (0.4) | 38 (0.35) | 27 | 109 | 0.25\* |
| Resolved | 26 (0.52) | 19 (0.38) | 5 | 50 | 0.1 |
| Totals |  | 308 | 61 | 606 | 975 |  |
| Description Only Shown at Time 1(DESCRIPTION ONLY) | Know |  | 162 (0.97) | 2 (0.01) | 3 | 167 | 0.02 |
| Don't Know | Unresolved | 60 (0.09) | 572 (0.86) | 35 | 667 | 0.05 |
| Resolved | 5 (0.83) | 1 (0.17) | 0 | 6 | 0 |
| TOT | Unresolved | 48 (0.55) | 18 (0.20) | 22 | 88 | 0.25\* |
| Resolved | 31 (0.78) | 3 (0.08) | 6 | 40 | 0.15 |
| Totals |  | 306 | 66 | 596 | 968 |  |

*ᵅ* Conditional probability of experiencing a TOT on the second test.

\**p* < 0.05 according to OR calculations in text.

**Chapter 5 – General Discussion**

**Over-Arching Goal**

 The over-arching goal of this dissertation was to provide insight on how humans produce speech, which is one of the three primary facets of language studied by psycholinguists (the other two being language acquisition and comprehension). As proposed by some of the most prominent cognitive scientists and linguists in the field, it is essential to study speech errors in order to comprehensively understand the core mechanisms of the word production system (e.g., Dell, 1986, Fromkin, 1973; Garrett, 1975).

 Spoken word production is the least studied facet of language, and it is therefore particularly important for the field of psycholinguistics to build upon the speech production literature in order to move the field forward. Traditionally the field has focused more on written language, and it is hypothesized that the disproportion of research between written and spoken language has been due to convenience in research design (Ferreira, 2005). Undeniably, a significant amount of time goes into recording and transcribing speech. Furthermore (and anecdotally), it is sometimes difficult to encourage participants to speak aloud as sometimes speakers are quite inhibited. This inhibition to speak aloud may arise from personality traits such as shyness, or perhaps the fear of speaking incorrectly.

 All three studies in this dissertation concerned the tip-of-the-tongue (TOT) state, and specifically repeated TOT states. TOT states are particularly useful in that the phenomenon gives psycholinguists the opportunity to observe the step-by-step process of spoken word production. TOT states have served to advance the field of spoken word production and have been the subject of some influential theories (e.g., Transmission Deficit Hypothesis) (Burke et al., 1991). As mentioned, the Transmission Deficit Hypothesis suggests that the TOT state occurs between the lemma and phonological units of the word production system. While Humphreys and colleagues agree that the lemma to phonological nodes are the locus of the TOT state, they argue that the TOT state is a specific state, whereby repeated TOT states are driven by an erroneous learning mechanism. However, the primary goal of this dissertation was to provide a more comprehensive understanding of the TOT state. While previous research by Humphreys and colleagues was focused on validating the error repetition effect (and in turn, an error learning interpretation of the error repetition effect), the studies in this dissertation were designed on the assumption that the error learning effect is a real effect (as evidenced by D’Angelo & Humphreys, 2015). The results across all three studies were consistent with previous findings that TOT states repeat at a rate greater than expected by chance, and I argue that the results outlined in my three studies point toward an error learning interpretation of the error repetition effect.

**Challenges in Word-Production Studies**

 The purpose of the abovementioned disclaimer is not to downplay the studies and findings within this dissertation. I have tackled research questions and research designs that are not typical within the field due to the many inconveniences and challenges that accompany these types of studies. For instance, in Study 1 (Chapter 2 – Phonological Interlopers Tend to Repeat When Tip-of-the-Tongue States Repeat), I undertook the research question of what is being learned during a TOT state. This research study was difficult for numerous reasons. First, there was a week between test and retest, which subsequently meant it was difficult to find participants. There was also the arduous task of transcribing the spoken utterances (recall that participants were given 15 seconds to think aloud during TOT and Don’t Know responses). Furthermore, I had to develop a complex and novel linguistic coding scheme to effectively account for the parameters of my research question, and in turn all utterances needed to be coded.

 Study 2 (Chapter 3 - Age is Associated with Recurring Tip-of-the-Tongue States Above and Beyond Cognitive Functioning), involved complex coordination and cooperation between numerous retirement home administrators, residents, and research assistants. Many hours were spent outside of the lab collecting data and building rapport with the participants so that they would feel comfortable participating in psychological experiments. There was also a 48-hour period between test and retest making it difficult to track down participants, especially given that retirement homes schedule many extracurricular activities. In turn, it took many months to reach an acceptable sample size. Furthermore, working with participants of advanced age and of various levels of cognitive functioning required a level of patience and understanding that is not typical within standard psycholinguistic research projects (although I would like to note that Study 2 was the most personally fulfilling). Gratefully, Study 3 (Chapter 4) was a more standard psycholinguistic study. I suspect that if I had not undertaken these projects, that the research questions asked within Study 1 and Study 2 would have never been empirically tested. In combination with these practical difficulties, the findings laid out in this dissertation are compelling in their own right, and are standalone studies that follow from the previous work done by Humphreys and colleagues on the error repetition effect.

**General Summary of the Results**

 The error repetition pattern was consistent across all three studies. TOT states were most likely to repeat at retest for a specific word if the TOT state for that same word was left unresolved on Test 1. Additionally, TOT states were less likely to repeat if the TOT state was self-resolved on Test 1. This pattern of error (i.e., TOT) repetition occurred under a variety of conditions; TOT states repeated in both young adults and older adults, and with a one week, 48-hour, and 5 minute delay between test and retest.

**Three Core Arguments**

 **The TOT state is specific in nature.**

 The results of Study 1 (Chapter 2) demonstrate that not only do errors repeat one week later for individual words but that interlopers and reports of partial information also repeat. The central finding is that when asking speakers to verbalize any information that comes to mind when they are trying to retrieve a word, if a TOT repeats a week later, the same information often repeats as well; this is over twice as likely for TOT trials than Don’t Know Trials. These findings demonstrate the importance of the role of phonology in the TOT state. While both Don’t Know and TOT responses in the think aloud protocol frequently contained semantic or episodic information, only the TOT responses showed sizable reports of (usually accurate) phonologically related information. The fact that the same information, especially phonologically related material, was reported a week apart on repeated TOT trials speaks directly to our research question about what is being learned in the error state. This finding supports the idea that the TOT state is an organized pattern of activation, providing an opportunity for convergence on an erroneous state. The retrieval effort, especially a repeated one over a period of 15 seconds then reinforces the mapping from lemma to that specific incorrect phonological state. Then, during a subsequent retrieval attempt, that incorrectly reinforced mapping is followed, leading to the same (or at least highly similar) erroneous state, complete with repeated partial information. The learning via Hebbian reinforcement of a specific alternate state provides a plausible mechanism underlying an error learning explanation of the error repetition effect.

 Study 2 (Chapter 3) found that the error repetition effect is present within an older sample, which was expected. The presence of an error repetition effect provides evidence that the tendency for TOT states to repeat is not unique to a young and healthy population, but rather can be generalized to an older population. I argue that this finding in and of itself is support for the validity of the error repetition effect as generalizability is an important step in validating research findings. However I will acknowledge that given the relatively small sample sizes within this dissertation, I cannot fully generalize my findings. The results are strong evidence to support that older adults show the same kinds of error repetition patterns as found in young adults and though the error learning effect was not directly tested in this study, the results are suggestive of an error learning mechanism (i.e., a specific state). It is possible that the error repetition effect in older adults can at least partially be explained by a Hebbian-like error learning mechanism whereby the incorrect mappings between the lemma and phonology are learned (D’Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Older adults may be especially vulnerable to the error learning effect due to a weakened word production system. As evidenced by the resolution effect, it may be that a TOT state can be unlearned through an active self-driven search. A successful search for the correct word may reinforce the correct phonological pattern for the target word, so that when the word is encountered again in the future, one is more likely to access the correct answer. Conversely, when a word search fails (i.e., the correct answer is not found) the incorrect lemma to phonology mappings may be strengthened, increasing the likelihood that a TOT state is repeated in the future.

 While Study 3 (Chapter 4) did not provide direct evidence for an error learning effect, it provided evidence against the metacognitive account of TOT states. Study 3 specifically provided evidence that the error learning effect (see D’Angelo & Humphreys, 2015 for an in depth review) cannot be explained by a metacognitive mechanism. I argue that this study provides indirect support for the error learning account of repeated TOT states.

 **TOT states are not a bad thing.**

 Study 2 found that the correlation between age and the probability of repeating a TOT state was significant. An increase in TOT states was not significantly correlated with dementia as measured by MoCA scores, but those with higher MoCA scores were better at self-resolving TOT states. After partialing out the MoCA scores, age remained a significant predictor of the tendency for TOT states to repeat. That is, as age increased, the tendency to repeat a TOT state for a specific word increased. MoCA scores were not found to be significantly associated with repeated TOT states. This result constitutes strong evidence to suggest that repeated TOT states are not driven by cognitive impairment, but are rather a part of normal aging.

 **TOT states are not a metacognitive phenomenon.**

 Recall that metacognition researchers view the TOT state as the subjective feeling of temporary inaccessibility, placing focus on the dissociation between the subjective experience of a TOT state and word retrieval processes that occur in the speech production system (e.g., Schwartz, 2001). The primary finding across both experiments in Study 3 is that the error repetition effect—the tendency for TOTs to repeat at a rate greater than can be predicted by chance—does not differ between identical prompts (as used in the original TOT paradigm) and alternative prompts. In other words, whether participants were given the same definitions or different definitions on test and retest, the nature of the error repetition effect remained the same. Furthermore, when the degree of differentness was manipulated in the cues in Experiment 2 (pictures versus description), there was still no significant difference in the likelihood of repeating a TOT state between identical and alternative prompt conditions. I argue that this finding is not well explained by a metacognitive account. If TOT states are primarily the product of a metacognitive mechanism, we should have found that those who are given identical prompts (i.e., cues) across test and retest are more likely to experience a repeated TOT state. One could argue that the picture and description prompts are giving participants the same type of information, which is why there was no difference between the very different cue condition and the identical condition. In turn, we decided to more directly test the role of semantics in the error repetition effect. We found that providing an extra semantic cue did not lead to an increase in the likelihood of repeating a TOT state. Therefore, I argue for a specific breakdown between the lemma and phonological level of the word production system, and furthermore, that it is this particular erroneous mapping that can be learned, giving rise to the error repetition effect.

**Future Directions**

There are many directions that could be taken with the error repetition effect literature, some of which I am currently working on. As mentioned in Study 3, metacognition researchers speculate that speakers are using educated guessing to report phonological properties of a target word during a TOT state (Cleary & Claxton, 2015). In other words, when speakers are reporting phonological information, these reports are not indicative of partial phonological access. I am currently undertaking a research project that asks the research question: are speakers using educated guessing to report phonological information during a TOT state? If speakers are guessing phonological information, then there should be a higher proportion of reported phonological information in the high frequency phonosyntactic condition than the low frequency phonosyntactic condition (i.e., it is easier to guess high frequency components of a word). I hypothesize that I will find that there is no difference between the two conditions, which will further support the phonological failure account of TOT state etiology.

 Considering that Study 2 is the first study to examine the error repetition effect using the Warriner and Humphreys’ (2008) methodology in older adults, and is the first study ever to explore the tendency for TOT states to repeat on the cognitive functioning continuum, there is much work to be done in an older population. There is increased uncertainty surrounding the differences and similarities between proper and common nouns. Studies have shown that in older adults, proper names are significantly more difficult to produce than other word types (e.g., Burke et al., 1991; Cohen & Faulkner, 1986). I am currently investigating the nature of proper versus common nouns in older adults using the repeated TOT paradigm used by Humphreys and colleagues.

 The next major step to move the error repetition hypothesis (and therefore the error learning hypothesis) forward is to computationally model error learning. It may be of most interest to use data collected on older adults. As mentioned, Study 2 of this dissertation did not directly test whether the error repetition effect found in older adults is the result of an error learning mechanism (though we do argue the results point in that direction). Therefore, the first step would require the full set of experiments that were undertaken by D’Angelo and Humphreys (2015) to find evidence of error learning in older adults. The caveat to this proposal is that it takes a significant amount of time and resources (more than a single graduate student can take on) to perform the D’Angelo and Humphreys (2015) experiments in a large sample of older adults. Although note that I recruited my participants from the wider Southern Ontario community and ventured out into these communities myself, these projects could be feasible with healthy older adults who are willing to travel to a lab. If the error learning account of the error repetition effect can be validated in an older population, then these data could be modeled. Recall that there is a sizeable correlation between the tendency for TOT states to repeat and age. With age, the connections within the word production system weaken, especially the lemma to phonology connections (as described in Abrams & Farrell, 2010; Burke & Shafto, 2008; Mortensen et al., 2006), which in turn leads to more TOT states. If connections become increasingly weakened with age, then there are going to be large consequences for making an error (i.e., selecting the wrong pathway to the target word). There is also the cognitive functioning parameter, where weakening of the word production connections becomes so extensive that there is not enough activation to reach successful lemma access, leading to fewer repeated TOT states. The age and cognitive functioning parameters would make for an interesting model of word production failure, and may increase interest in the error learning literature.

**Take-Home Message**

 The results from the three studies demonstrate and support the importance of the lemma-to-phonological units of the word production system. All of the results point toward the phonological failure account of the TOT state, which is in accordance with the psycholinguistic literature. However, the TOT state may best be described as a specific state rather than a general state, whereby there is an underlying erroneous learning mechanism. I argue that the evidence in this dissertation has demonstrated that the TOT state may be best described as a specific rather than general subthreshold state, the error repetition effect can be generalized to an older population, and I was able to find evidence against a metacognitive account of TOT states.

**Final Thoughts**

 Having the opportunity to study psycholinguistics has been a thought-provoking and sometimes unusual experience. Unlike other branches of cognitive psychology such as memory and learning, psycholinguistics does not fit neatly into a theoretical box. Psycholinguists have the additional challenge of being expected to explain how linguistic processes fit in with the more often studied aspects of cognition such as memory (Ferreira, 2005). Additionally, psycholinguists must borrow theory from both linguistics and psychology (Dell, 1986; Derwing, 1988). For instance, in prominent spoken word production models, one must consider the structure of language, which is borrowed from linguistics. In conjunction with linguistic assumptions, one must also consider prominent cognitive models, such as McClelland and Rumelhart’s (1981) interactive spreading activation model. I describe myself as a staunch cognitive psychologist over a linguist, as I am primarily interested in the cognitive properties and experimental findings of language. Yet, as a psycholinguist, I am able to appreciate that the field originated from an assortment of schools of thought. Anecdotally, given that psycholinguistics is one of the more multidisciplinary branches of cognition, it has sometimes been difficult to establish the work laid out in this dissertation. However, it has been a fulfilling and alluring challenge that I would not trade for anything.

**References**

Abrams, L. & Farrell, M.T. (2011). Language processing in normal aging. In Guendouzi, J., Loncke, F., & Williams, M. J. (Eds.), *The handbook of psycholinguistic and cognitive processes: Perspectives in communication disorders* (pp. 49–73). New York, NY: Psychology Press.

Alzheimer, A. 1907. A characteristic disease of the cerebral cortex. In K. Bick, L. Amaducci, & G. Pepeu (Eds. & Trans.) (1986). *The early story of Alzheimer’s disease.* Padua, Italy: Liviana Press.

Astell, A. J., & Harley, T. A. (1996). Tip-of-the-tongue states and lexical access in dementia. *Brain and Language*, *54*(2), 196–215.

Badecker, W., Miozzo, M., & Zanuttini, R. (1995). The two-stage model of lexical retrieval: Evidence from a case of anomia with selective preservation of grammatical gender. *Cognition*, *57*(2), 193–216.

Beeson, P. M., Holland, A. L., & Murray, L. L. (1997). Naming famous people: An examination of tip-of-the-tongue phenomena in aphasia and Alzheimer's disease. *Aphasiology*, *11*(4-5), 323–336.

Brennen, T., Baguley, T., Bright, J., & Bruce, V. (1990). Resolving semantically induced tip-of-the-tongue states for proper nouns. *Memory & Cognition*, *18*(4), 339–347.

Brown, A. S. (1991). A review of the tip-of-the-tongue experience. *Psychological Bulletin*, *109*(2), 204–223.

Brown, R., & McNeill, D. (1966). The “tip of the tongue” phenomenon. *Journal of Verbal Learning and Verbal Behavior*, *5*(4), 325–337.

Brown, A.S., & Nix, L.A. (1996). Age-related changes in the tip-of-the-tongue experience. *The American Journal of Psychology*, *109*(1), 79–91.

Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults? *Journal of Memory and Language*, *30*(5), 542–579.

Burke, D. M., & Shafto, M. A. (2008). Language and aging. In F.I.M. Craik & T.A. Salthouse (Eds.)*, The Handbook of Aging and Cognition* (pp. 373–443). New York: Psychology Press.

Clare, L., Wilson, B. A., Carter, G., Breen, K., Gosses, A., & Hodges, J. R. (2000). Intervening with everyday memory problems in dementia of Alzheimer type: An errorless learning approach. *Journal of Clinical and Experimental Neuropsychology*, *22*(1), 132–146.

Cleary, A. M., & Claxton, A. B. (2015). The tip-of-the-tongue heuristic: How tip-of-the- tongue states confer perceptibility on inaccessible words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(5), 1533–1539.

Cohen, G., & Faulkner, D. (1986). Memory for proper names: Age differences in retrieval. *British Journal of Developmental Psychology*, *4*(2), 187–197.

Dahlgren, D. J. (1998). Impact of knowledge and age on tip-of-the-tongue rates. *Experimental Aging Research, 24*, 139–197.

DʼAngelo, M. C., & Humphreys, K. R. (2015). Tip-of-the-tongue states reoccur because of implicit learning, but resolving them helps. *Cognition*, *142*, 166–190.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *93*(3), 283–321.

Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological review*, *104*(4), 801– 838.

Derwing, B. L. (1988). Psychology, psycholinguistics and cognitive ccience: Is there a place for linguistics? *Deseret Language and Linguistic Society Symposium*, *14*(1), 227–243.

Dunn, L.M., & Dunn, D.M. (2007). Peabody Picture Vocabulary Test, Fourth Edition.

Farrell, M. T., & Abrams, L. (2011). Tip-of-the-tongue states reveal age differences in the syllable frequency effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(1), 277–285.

Ferreira, F. (2005). Psycholinguistics, formal grammars, and cognitive science. *The Linguistic Review*, *22*(2-4), 365–380.

Fromkin, V.A. (ed.) (1973) *Speech errors as linguistic evidence*. The Hague, The Netherlands: Mouton.

Garrett, M. F. (1975). The analysis of sentence production. In Gordon H. Bower (Ed.), *The psychology of learning and motivation*, (pp. 133–175). San Diego: Academic Press.

Gollan, T.H., & Brown, A.S. (2006). From tip-of-the-tongue (TOT) data to theoretical implications in two steps: When more TOTs means better retrieval. *Journal of Experimental Psychology, 3*, 462–483.

Harley, T. A., & Bown, H. E. (1998). What causes a tip‐of‐the‐tongue state? Evidence for lexical neighbourhood effects in speech production. *British Journal of Psychology*, *89*(1), 151–174.

Heine, M. K., Ober, B. A., & Shenaut, G. K. (1999). Naturally occurring and experimentally induced tip-of-the-tongue experiences in three adult age groups. *Psychology and Aging*, *14*(3), 445–457.

Humphreys, K. R., Menzies, H., & Lake, J. K. (2010). Repeated speech errors: Evidence for learning. *Cognition*, *117*(2), 151–165.

James, W. (1890). *The principles of psychology: Vol. 1*. New York: Holt.

Jones, G.V. (1989). Back to Woodworth: Role of interlopers in the tip-of-the-tongue phenomenon. *Memory & Cognition, 17*(1), 69–76.

Juncos-Rabadan, Facal, Rodriguez, & Periero, A.X. (2010). Lexical knowledge and lexical retrieval in ageing: Insights from a tip-of-the-tongue (TOT) study. *Language and Cognitive Processes, 25*(10), 1301–1334.

Kempen, G., & Huijbers, P. (1983). The lexicalization process in sentence production and naming: Indirect election of words. *Cognition*, *14*(2), 185–209.

Koriat, A., & Lieblich, I. (1977). A study of memory pointers. *Acta Psychologica*, *41*(2- 3), 151–164.

Laffan, A. J., Metzler-Baddeley, C., Walker, I., & Jones, R. W. (2010). Making errorless learning more active: Self-generation in an error free learning context is superior to standard errorless learning of face–name associations in people with Alzheimer's disease. *Neuropsychological Rehabilitation*, *20*(2), 197–211.

Levelt, W. J. M. (1989). *Speaking. From intention to articulation*, Cambridge, MA: MIT Press.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*(01), 1–38.

Levelt, W. J. M. (2001). Spoken word production: A theory of lexical access. *Proceedings of the National Academy of Sciences*, *98*(23), 13464–13471.

Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology*, *49*(4), 764–766.

MacKay, D.G. (1987). *The organization of perception and action: A theory for language and other cognitive skills*. New York: Springer Verlag

MacKay, D.G., & Burke, D.M. (1990). Cognition and aging: A theory of new learning and the use of old connections. In T. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization* (pp. 213-263). Amsterdam: North Holland.

Metcalfe, J., Schwartz, B. L., & Joaquim, S. G. (1993). The cue-familiarity heuristic in metacognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(4), 851–861.

Meyer, A.S., & Bock, K. (1992). The tip-of-the-tongue phenomenon: Blocking or partial activation? *Memory and Cognition, 20*(6), 715–726.

Middleton, E.L., & Schwartz, M.F. (2013). Learning to fail in Aphasia: An investigation of error learning in naming. *Journal of Speech, Language, and Hearing Research, 56*, 1287–1297.

Miozzo, M., & Caramazza, A. (1997). Retrieval of lexical–syntactic features in tip-of-the tongue states. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(6), 1410–1423.

Mortensen, L., Meyer, A. S., & Humphreys, G. W. (2006). Age-related effects on speech production: A review. *Language and Cognitive Processes*, *21*, 238–290.

Nasreddine, Z.S., Phillips, N.A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J.L., Chertkow, H. (2005). The Montreal Cognitive Assessment (MoCA): A Brief Screening Tool for Mild Cognitive Impairment. *Journal of the American Geriatrics Society, 53*, 69–699.

Oppenheim, G. M., Dell, G. S., & Schwartz, M. F. (2010). The dark side of incremental learning: A model of cumulative semantic interference during lexical access in speech production. *Cognition*, *114*(2), 227–252.

Page, M., Wilson, B. A., Shiel, A., Carter, G., & Norris, D. (2006). What is the locus of the errorless-learning advantage? *Neuropsychologia*, *44*(1), 90–100.

Rastle, K. G., & Burke, D. M. (1996). Priming the tip of the tongue: Effects of prior processing on word retrieval in young and older adults. *Journal of Memory and Language*, *35*(4), 586–605.

Roelofs, A. (1997). The WEAVER model of word-form encoding in speech production. *Cognition*, *64*(3), 249–284.

Salthouse, T.A., & Mandell, A.R. (2013). Do age-related increases in tip-of-the-tongue experiences signify episodic memory impairments? *Psychological Science, 24*(12), 2489–2497.

Schwartz, B. L. (1999). Sparkling at the end of the tongue: The etiology of tip-of-the- tongue phenomenology. *Psychonomic Bulletin & Review*, *6*(3), 379–393.

Schwartz, B. L. (2001). *Tip-of-the-tongue states: Phenomenology, mechanism, and lexical retrieval.* Hillsdale, NJ: Erlbaum.

Schwartz, B. L. (2006). Tip-of-the-tongue states as metacognition. *Metacognition and Learning*, *1*(2), 149–158.

Schwartz, B. L., & Frazier, L. D. (2005). Tip-of-the-tongue states and aging: Contrasting psycholinguistic and metacognitive perspectives. *The Journal of General Psychology*, *132*(4), 3 77–391.

Schwartz, B.L, & Metcalfe, J. (2011). Tip-of-the-tongue (TOT) states: Retrieval, behavior, and experience. *Memory & Cognition, 39*, 737–749.

Terrace, H. S. (1963). Discrimination learning with and without “errors”. *Journal of the Experimental Analysis of Behavior*, *6*(1), 1–27.

Tulving, E. (1989). Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology*, *1*(1), 3–26.

Vigliocco, G., Antonini, T., & Garrett, M. F. (1997). Grammatical gender is on the tip of Italian tongues. *Psychological science*, *8*(4), 314–317.

Vitevitch, M. S. (2002). The influence of phonological similarity neighborhoods on speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(4), 735–747.

Warriner, A.B, & Humphreys, K.R. (2008). Learning to fail: Reoccurring tip-of-the- tongue states. *The Quarterly Journal of Experimental Psychology, 61*(4), 535– 542.

**Appendices**

**Appendix A**

Target

|  |
| --- |
| nectar |
| audience |
| dermatologist |
| gurney |
| abacus |
| apron |
| abdicate |
| plasma |
| onomatopoeia |
| lava |
| blubber |
| glider |
| subpoena |
| alchemy |
| arson |
| alimony |
| mausoleum |
| photosynthesis |
| origami |
| gill |
| farm |
| spatula |
| sextant |
| scapegoat |
| catalyst |
| odometer |
| cartographers |
| scarab |
| regatta |
| kaleidoscope |
| procrastinate |
| filibuster |
| ostrich |
| forfeit |
| trachea |
| jettison |
| shamrock |
| clavicle |
| slalom |
| perjury |
| filament |
| ellipsis |
| obsidian |
| contraband |
| ornithology |
| spelunkers |
| incubate |
| spike |
| chalice |
| martyr |
| gargoyle |
| station |
| quarantine |
| metronome |
| ventriloquist |
| trellis |
| treason |
| vineyard |
| labyrinth |
| armada |
| parasite |
| planetarium |
| javelin |
| decanter |
| philanthropy |
| guillotine |
| allergy |
| pseudonym |
| axe |
| tranquilizer |

**Appendix B**

Target:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|

|  |
| --- |
| abacus |
| alimony |
| allergy |
| apron |
| armada |
| arson |
| audience |
| axe |
| blubber |
| cent |
| chalice |
| clavicle |
| contraband |
| decanter |
| ellipsis |
| farm |
| filament |
| forfeit |
| gargoyle |
| gill |
| glider |
| guillotine |
| incubate |
| javelin |
| jettison |
| kaleidoscope |
| lava |
| metronome |
| nectar |
| odometer |
| origami |
| ostrich |
| perjury |
| procrastinate |
| pseudonym |
| shamrock |
| spatula |
| spike |
| treason |
| trellis |
| ventriloquist |
| vineyard |

 |

**Appendix C**



List of Warriner and Humphreys (2008) Definition Prompts

1. "What do you call an instrument for performing calculations by sliding beads along rods or grooves?"
2. "What do you call money paid to one spouse by the other for support during or after divorce or separation?"
3. "What do you call a policy of racial segregation formerly practiced in the Republic of South Africa?"
4. "What do you call a person who makes maps?"
5. "What do you call a substance that a substance that changes the rate of a chemical reaction but is itself unchanged at the end of the process?"
6. "What do you call three periods (...) used to indicate an omission or a pause?"
7. "What do you call a wire (as in a light bulb) that is made to glow by the passage of an electric current?"
8. "What is the name of a waterspout in the form of a strange or frightening human or animal figure sticking out at the roof or eaves of a building?"
9. "What do you call a device for beheading a person by means of a heavy blade that is dropped between two posts serving as guides?"
10. "What do you call a flat, padded table or stretcher with legs and wheels, for transporting patients or bodies?"
11. "What is the word for keeping eggs warm until they hatch?"
12. "What is the name of the spear-like object that is thrown during a track meet?"
13. "What do you call a tube containing loose bits of colored glass or plastic and two mirrors at one end that shows many different patterns as it is turned?"
14. "What do you call a person who suffers death rather than give up his or her religion?"
15. "What is the name of the device which indicates tempo in music by means of a pendulum?"
16. "What is the name of an instrument for measuring distance traveled (as by a vehicle)?"
17. "What do you call the use of words such as buzz or murmur that imitate the sounds associated with the objects or actions they refer to?"
18. "What is the name of the Japanese art of folding paper into shapes?"
19. "What do you call an organism that lives on or in an organism of another species, known as the host, from the body of which it obtains nutriment?"
20. "What do you call false testimony while under oath?"
21. "What do you call a spirit of goodwill toward all people especially when expressed in active, charitable and generous efforts to help others?"
22. "What do you call a building for the display of projected images of the stars for educational purposes?"
23. "What do you call a fictitious name used by an author to conceal his or her identity; pen name?"
24. "What do you call the situation where patients suffering from a contagious disease are isolated in order to prevent the spread of disease?"
25. "What do you call someone who bears the blame for others?"
26. "What do you call the representation or image of a beetle, much used among the ancient Egyptians as a symbol, seal, amulet, or the like?"
27. "What do you call a timed skiing race over a zigzag or wavy course between upright poles?"
28. "What is the name of the instrument used for turning pancakes, eggs, etc.?"
29. "What do you call a court order compelling a witness to be present at a trial or hearing, under penalty of fine or imprisonment?"
30. "What is the name of the crime in which a person purposely betrays his country?"
31. "What do you call one who speaks with little or no lip movement so his/her voice appears to come from another source such as a wooden dummy?"
32. "What is it called when the body has an abnormal reaction to a normally harmless substance?

33."What is the name of the lizard that changes its color to match the surroundings?

1. "What do you call the act of losing or surrendering something as a penalty for a mistake or fault or failure to perform etc.?"
2. "What is the term for the teaching or practical lesson contained in a fable, tale, experience, etc.?"
3. What is the name of the sweet liquid given off by plants and especially by the flowers and used by bees in making honey?"
4. "What is the name of the bird that cannot fly and is the largest bird on earth?"
5. "What is the name of the process by which plants make their food?"
6. "What do you call the liquid part of blood or lymph, as distinguished from the suspended elements?"
7. "What do you call it when you defer action or consistently put things off 'until tomorrow'?"
8. "What is the name for the body's principle air passage; the medical name for windpipe?"
9. "What do you call a plantation that produces grapes?"
10. “What do you call any of various drugs used for treating allergic reactions and cold symptoms?”
11. “What do you call the freeing (as by verdict) of a person from the charge of a crime?”

List of WordNet Definition Prompts

1. "What do you call a calculator that performs arithmetic functions by manually sliding counters on rods or in grooves?"
2. "What is court-ordered support paid by one spouse to another after they are separated called?"
3. "What was the 20th century, South African policy of racial segregation called?"
4. "What do you call a professional map-maker?"
5. "What is a name for something that can cause an important event to happen?"
6. "What do you call a series of dots that indicates a pause or omission?"
7. "What do you call a thin wire that is heated white hot by electric current?"
8. "What do you call a decorative, carved, grotesque figure?"
9. "What is the name of the decapitation device popularized during the French Revolution?"
10. "What do you call a metal stretcher with wheels, regularly used to transport hospital patients?"
11. "What is the word for keeping organisms at a suitable temperature so that they can develop?"
12. "What is the name of a light spear which can be thrown as a weapon, or thrown in competitive events?"
13. "What do you call a cylinder with mirrors and beads that appears to have a pattern of changing colours and shapes?"
14. "What do you call a person who dies rather than renounce their beliefs?"
15. "What is the name of the device which produces regular beats and is used by musicians to maintain an exact tempo?"
16. "Which component of a vehicle measures distance travelled?"
17. "What is a word that sounds like its meaning called?"
18. "What is the Japanese art of paper folding called?"
19. "What do you call an organism that lives harmfully on or in a host organism?"
20. "What is the crime of making false statements under oath called?"
21. "What are charitable actions taken by businesses and governments usually referred to?"
22. "What do you call a theatre used for shows that educate about astronomy?"
23. "What do you call a fictitious name used particularly by authors)?"
24. "What is the word for medically-imposed isolation?"
25. "What do you call someone who is blamed for the errors of others?"
26. "Which beetle was considered divine by ancient Egyptians?"
27. "What do you call a downhill ski race that takes place down a winding course marked with flags or poles?"
28. "What is the name of the kitchen tool with a thin, flexible blade?"
29. "What is a court order compelling a witness to be present at a trial or hearing called?"
30. "What is it called when someone betrays their country or government?"
31. "What do you call someone who can project their voice so that it seems to come from another source (such as a dummy)?"
32. "What is it called when the body has a hypersensitive immune response to a non- harmful substance?"
33. "Which lizard can change its colouring to better match its surroundings"?
34. "What is it called when someone loses a competition by voluntarily withdrawing?"
35. "What is the term for a lesson that is learned from a story?"
36. "What is the name the sweet, liquid, secretion that is used by plants to attract pollinators?"
37. "Which flightless bird is also the world's largest?"
38. "What is the name for the process used by plants to transform light energy into glucose?"
39. "What is the name for the liquid in which blood cells are suspended?"
40. "What is it called when someone postpones what they should be doing?"
41. "What is the name of the tube that allows air to reach the lungs?"
42. "What do you call a plantation of grape-bearing vines?"
43. "What are the drugs that are used to treat seasonal allergies called?"
44. "What is a word beginning with "a" that is used to describe a "not guilty" verdict?"

**Appendix D**

|  |  |
| --- | --- |
| Target name | Description |
| Amanda Seyfried | She starred as Karen Smith in Mean Girls and appeared in Jennifer's Body, In Time and Les Miserables |
| Amy Adams | She starred as Lois Lane in Man of Steel, Giselle in Enchanted and Julie Powell in Julie & Julia |
| Andrew Garfield | He starred as Peter Parker/Spiderman in The Amazing Spiderman and Eduardo Saverin in The Social Network |
| Ben Stiller | He starred as Derek Zoolander in Zoolander and appeared in Tropic Thunder and the Madgascar series |
| Blake Lively | She starred as Serena van der Woodsen in Gossip Girl, Carol Ferris in Green Lantern and Bridget in Sisterhood of the Travelling Pants |
| Bruce Willis | He starred as John McClane in the Die Hard series and in the movies, The Sixth Sense and The Fifth Element |
| Cate Blanchett | She starred as Galadriel in The Lord of the Rings trilogy, Queen Elizabeth I in Elizabeth and Daisy in The Curious Case of Benjamin Button  |
| Chris Pine | He starred as James Kirk in the recent 2009 and 2013 Star Trek remakes |
| Colin Farrell | He starred in the movies Total Recall (2012), Fright Night, Phone Booth and Alexander |
| Daniel Radcliffe | He starred as Harry Potter in the Harry Potter series |
| Dennis Quaid | He starred as climatologist Jack Hall in the The Day After Tomorrow |
| Dustin Hoffman | He starred as Raymond Babbit in Rain Man, Ted Kramer in Kramer Vs Kramer and Bernie Focker in Meet the Fockers |
| Elijah Wood | He starred as Frodo Baggins in The Lord of the Rings trilogy and Ryan in the TV series, Wilfred |
| Emma Stone | She starred as Gwen Stacy in The Amazing Spiderman and appeared in The Help, Easy A and Zombieland |
| Eric Bana | He starred as Hector in Troy, Bruce Banner in Hulk (2003) and Nero in Star Trek (2009) |
| Ewan McGregor | He starred as Obi Wan Kenobi in Star Wars: Episodes I-III, Ed Bloom in Big Fish and Camerlengo Patrick McKenna in Angels & Demons |
| Gary Oldman | He starred as Commissioner Jim Gordon in the Dark Knight trilogy and Sirius Black in the Harry Potter series. |
| Gemma Arterton | She starred as Gretel in Hansel & Gretel: Witch Hunters and Bond girl, Strawberry Fields in Quantum of Solace |
| Gerard Butler | He starred as King Leonidas in 300 and in the movies, P.S. I Love You, The Ugly Truth and Gamer |
| Hayden Christensen | He starred as Anakin Skywalker in the Star Wars series and appeared in Jumper |
| Heath Ledger | He starred as Joker in The Dark Knight, Ennis Del Mar in Brokeback Mountain and William Thatcher in A Knight's Tale |
| Hugh Grant | He starred in the movies, Love Actually, Bridget Jones's Diary, Sense and Sensability and Four Weddings and a Funeral |
| James Marsden | He starred as Cyclops in the original X-men trilogy and appeared in Hairspray and 27 Dresses |
| Jason Statham | He starred in the movies, Transporter series, Crank series, The Expendables and Snatch |
| Jeff Bridges | He starred as Jeffrey Lebowski/The Dude in The Big Lebowski, Kevin Flynn in the Tron series and Rooster in True Grit |
| Jennifer Lawrence | She starred as Katniss Everdeen in The Hunger Games, Mystique in X-Men: First Class and Tiffany in Silver Linings Playbook |
| Jesse Eisenberg | He starred as Mark Zuckerberg in The Social Network and Columbus in Zombieland |
| Jessica Biel | She starred in the movies, Blade Trinity, The A-Team and Total Recall |
| Joaquin Phoenix | He starred as Johnny Cash in Walk the Line and Emperor Commodus in Gladiator |
| Justin Long | He starred in the movies, Dodgeball, Accepted, Live Free or Die Hard and Drag Me to Hell |
| Kate Beckinsale | She starred as the vampire Selene in the Underworld series and appeared in Total Recall and Contraband |
| Kate Hudson | She starred in the movies, How to Lose a Guy in 10 Days, Bride Wars and You, Me, and Dupree |
| Kate Winslet | She starred as Rose Bukater in Titantic and in the movies, Eternal Sunshine of the Spotless Mind and Revolutionary Road |
| Keifer Sutherland | He starred as Jack Bauer in 24 and David in The Lost Boys |
| Keira Knightley | She starred as Elizabeth Swann in the Pirates of the Caribbean, Elizabeth Bennet in Pride & Prejudice and Anna Karenina in Anna Karenina |
| Kirsten Dunst | She starred as Mary Jane Watson in the Spiderman trilogy and Marie Antoinette in Marie Antoinette |
| Kristen Bell | She starred as Veroncia Mars in the Veroncia Mars series and in the movies, Forgetting Sarah Marshall, When in Rome and Couples Retreat |
| Liam Neeson | He starred as Ra's Al Ghul in the Dark Knight trilogy, Qui-Gon Jinn in Star Wars Episode I and II and Hannibal in The A-Team |
| Mark Wahlberg | He starred in the movies, The Fighter, The Departed, The Italian Job and Boogie Nights |
| Matt Damon | He starred as Jason Bourne in the Bourne Trilogy and appeared in The Departed and Ocean's Eleven trilogy |
| Matt Dillon | He starred as Dallas Winston in The Outsiders, Rusty James in Rumblefish and Healy in There's Something About Mary |
| Matt LeBlanc | He starred as Joey Tribbiani in the TV series Friends and its spinoff, Joey |
| Mel Gibson | He starred as William Wallace in Braveheart, Martin Riggs in the Lethal Weapons series and Graham Hess in Signs |
| Meryl Streep | She starred as Julia Child in Julie & Julia, Miranda Priestly in The Devil Wears Prada and Donna in Mamma Mia! |
| Milla Jovovich | She starred as Alice in the Resident Evil series and in the movies, Ultraviolet and The Fifth Element |
| Nicole Kidman | She starred in the movies, Moulin Rouge, The Golden Compass and The Others |
| Orlando Bloom | He starred as Legolas in The Lord of The Rings trilogy and Will Turner in Pirates of the Caribbean |
| Paul Rudd | He starred in the movies Role Models, I Love You Man, Anchorman and Knocked Up |
| Penelope Cruz | She starred in the movies Blow, Vanilla Sky, Volver and Pirates of the Caribbean: On Stranger Tides |
| Pierce Brosnan | He starred as James Bond in GoldenEye, Tomorrow Never Dies, Die Another Day and The World Is Not Enough |
| Reese Witherspoon | She starred as Elle Woods in the Legally Blonde series and June Carter in Walk The Line |
| Robin Williams | He starred as Mork in Happy Days and in the movies Dead Poets Society, Flubber and Jumanji |
| Rupert Grint | He starred as Ron Weasley in the Harry Potter series |
| Russell Crowe | He starred as Maximus in Gladiator and in the movies, A Beautiful Mind, Master and Commander, and 3:10 to Yuma |
| Salma Hayek | She starred in the movies Frida, Desperado and Once Upon a Time in Mexico |
| Sean Penn | He starred as gangster Mickey Cohen in Gangster Squad and appeared in Milk and I Am Sam |
| Steve Martin | He starred as Jacques Clouseau in The Pink Panther and Tom Baker in Cheaper By The Dozen |
| Tim Allen | He starred as the voice of Buzz Lightyear in the Toy Story series and in the TV series, Home Improvement |
| Tina Fey | She starred as Liz Lemon in the TV series 30 Rock and Claire Foster in Date Night |
| Viggo Mortensen | He starred as Aragorn in The Lord of The Rings trilogy and in the movies A History of Violence, Eastern Promises and The Road |

1. [↑](#footnote-ref-1)