



# Tip-of-the-tongue states reoccur because of implicit learning, but resolving them helps



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## ABSTRACT

In six experiments, we elicited tip-of-the-tongue (TOT) states, to investigate the novel finding that TOTs on particular words tend to recur for speakers, and examine whether this effect can be attributed to implicit learning of the incorrect mapping from a lemma to phonology for that word. We elicited TOTs by asking participants to supply the word that fit a given definition, and then retested participants on those same definitions in a second test. In Experiments 1–3 we investigated the time course of learning that occurs during TOTs, and found that TOTs are likely to recur with a five-minute test–retest interval, that this error learning can still be measured following a one-week interval, and that they recur for both monolingual and bilingual speakers. We also report the novel finding that error learning can be corrected when individuals resolve their TOT, making them less likely to re-experience a TOT for that word on a later test. In Experiment 4 we showed that these learning effects are not modulated by a priori knowledge of future tests. In Experiments 5a and 5b we show that orthographic cues can help individuals resolve their TOTs, and that these cued-resolutions lead to corrective learning in much the same way as self-resolutions. In Experiment 6 we demonstrate that effortful retrieval is critical to finding differences in error learning when manipulating the duration of unresolved TOTs. We conclude that the error-repetition effect is highly robust, and is best explained by implicit learning of the erroneous state. These findings reinforce the notion that the language production system is dynamic, and continually learning from experience, even when that experience is errorful.

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## 1. Introduction

The purpose of this paper is to investigate in detail the finding that tip-of-the-tongue (TOT) states tend to recur, described by Warriner and Humphreys (2008). That is, if a speaker experiences a TOT state on a particular word, they are more likely to experience a TOT on that same word the next time they attempt to retrieve it, despite having been previously told the correct answer. Furthermore, Warriner and Humphreys (2008) suggested that this is due to learning of that particular error state. In this paper we investigate the learning that occurs during tip-of-the-tongue states (TOTs), and delineate two effects: the tendency for TOTs on particular words to recur (the *error learning effect*), as well as corrective learning that arises when individuals resolve their TOTs (the *resolution effect*). We also investigate how this resolution effect occurs for both spontaneous and cued resolutions.

Tip-of-the-tongue states are ubiquitous experiences in language processing, in which individuals feel the imminent recall of a currently inaccessible word (Brown, 1991). TOTs are unique states in spoken word production, where individuals often have partial access to a currently inaccessible word, as is evidenced by the ability to report phonological and/or syntactic characteristics of the inaccessible word while in a TOT state (Brown, 1991; Brown & McNeill, 1966). From a psycholinguistic perspective, TOTs provide insight into the processes involved in word production, and are often described using a two-stage model of word production. There is wide agreement that word production is a multi-stage process in which word retrieval begins with a meaning-based retrieval stage that is followed by a form-based retrieval stage. In such models, activation proceeds from (non-linguistic) conceptual levels of representation, to lexico-syntactic levels of representation (i.e. lemmas, which contain syntactic information) and from there activates the corresponding phonological representation (e.g. Dell, 1986; Levelt, Roelofs, & Meyer, 1999; but see Caramazza & Miozzo, 1997 for a discussion of other ways in which lexico-syntactic information may be represented). Within these models that can be referred to as globally two-staged, there is

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some disagreement about the precise timing and directionality of information flow (e.g. see Rapp & Goldrick, 2000, for discussion). However, despite differences in proposals of how activation spreads, TOTs are often described in global two-stage models of production as reflecting the successful activation of a concept and then in turn the corresponding lemma, but unsuccessful or incomplete activation of the word's phonological information (e.g. Burke, MacKay, Worthley, & Wade, 1991; Gollan & Brown, 2006; Harley & Bown, 1998; Meyer & Bock, 1992). The incomplete or unsuccessful activation of phonological information that leads to a TOT state may be due to a number of factors that influence the strength of the connections between the lexical and phonological representations of a given word. For example, it has been shown that TOTs are experienced more often on words that have low frequency of use (e.g. Astell & Harley, 1996; Harley & Bown, 1998; Meyer & Bock, 1992; Vitevitch & Sommers, 2003), sparse phonological neighborhoods (e.g. Harley & Bown, 1998; Vitevitch & Sommers, 2003), low frequency of the initial syllable (e.g. Farrell & Abrams, 2011), as well as by words that have not been used recently (e.g. Burke et al., 1991); see Brown (2012, chap. 6) for a review of this literature. It is important to note that for a factor such as word frequency the underlying mechanism has to be that it is the frequency of that word for an individual speaker/listener that contributes to a predisposition to enter into a TOT state. As an operational definition, a word's frequency for an individual speaker can be estimated from population norms, but speakers will differ as to whether any particular word happens to be more or less frequent in their own experiences. Therefore, any word might be idiosyncratically difficult (or easy) for an individual to retrieve due to the interaction of a large number of potential factors, including the frequency with which that individual uses the word, the last time the word was used, the context in which the word is typically retrieved, and the other words present in the individual's lexicon, which influences the density and frequency of the phonological neighborhood.

### 1.1. Error learning in TOTs

Warriner and Humphreys (2008) set out to test two questions: first, whether speakers tend to repeat TOT states for individual words, and second, whether this is a result of learning the previously made error. To do this, they tested participants on definitions of rare words on two separate occasions. In the first test, participants read definitions of rare words and judged if they knew the word corresponding to the definition, did not know the word, or if they were in a TOT state. Forty-eight hours after the first test, participants read the same definitions and made the same judgment. The results showed that participants were over four times as likely to report a TOT on a word on the second test if they had reported a TOT on that same word during the first session, compared to if they had any other response on the first test. It is not overly surprising that words participants knew on Test 1 were words they were also able to correctly recall 48 h later, or that words they simply did not know were not later recallable after a single presentation of the correct answer. What is more surprising is the extent to which TOTs recurred. These were words that participants on Test 1 reported they knew, but could not quite articulate, and when presented with the correct answer confirmed that it was indeed the word they had been trying to retrieve. (For items where participants indicated that the presented answer was not the word they had been trying to retrieve, those trials were counted as invalid). However for more than one in four of those items, participants reported another TOT the next time they tried to retrieve it, 48 h later. In several ways, this is quite counter-intuitive. TOTs can constitute a state of intense frustration, leading to a palpable feeling of relief upon the provision of the

correct answer, and a feeling that one "knew it all along" (Brown, 1991). That one would not know the word on subsequent attempts, but instead frequently end up in another TOT state is at the very least extremely annoying, and on naïve introspection, quite surprising. How could one forget that again, after the flood of recognition earlier? Of course, one possible explanation for repeated TOTs is that some items are just more idiosyncratically difficult for individual speakers, so it is not surprising that an item that is difficult to retrieve once is likely to create subsequent retrieval difficulties. Warriner and Humphreys (2008), however, argued that the error-repetition effect they observed went beyond idiosyncratic difficulties with particular items, and represented a situation in which it was the act itself of making the error that contributed to making the error likely to recur. They argued that experiencing a TOT state for a particular word constitutes an implicit learning event for that incorrect pattern of activation (particularly the activation between a word's lemma and phonology), making a subsequent TOT for that same word more likely.

Although the definitions of infrequent words used to experimentally elicit TOTs tend to create a relatively high rate of errors, it is difficult to reliably experimentally manipulate whether an error on any given word occurs or not (although see also studies of phonological priming, e.g. Burke, Locantore, Austin, & Chae, 2004). This makes it a difficult matter to distinguish between an error-learning and an item-specific difficulty account. However, to distinguish between the two possibilities Warriner and Humphreys (2008) used an alternative method to approximate an experimental manipulation of error occurrence; instead of manipulating whether an error occurred, they manipulated the degree of error learning that took place, by varying the amount of time participants stayed in a TOT state. Specifically, when participants indicated that they did not know the word or were in a TOT state, they were randomly assigned to either a short (10 s) or long (30 s) delay period. During this delay period, participants were encouraged to try to retrieve the target word. At the end of the attempted retrieval period, participants were shown the correct word, and they verified whether or not it was the word they had been trying to retrieve. Critically, the authors hypothesized that more error learning would occur on items that elicited TOTs when participants were assigned to a long delay on the initial test, compared to a short delay on the initial test, as every additional failed retrieval attempt during the delay time would strengthen that incorrect retrieval pathway. Indeed, Warriner and Humphreys found that participants were almost twice as likely to re-experience a TOT on the second test for the items that had been assigned to a long delay on the first test, than on the items that had been assigned to a short delay on the first test.

Warriner and Humphreys (2008) suggested that the error repetition effect was a learning effect, reflecting adjustments made in the connection weights between the representation of the word's lemma and the representations of the phonological form that are currently active during a TOT state (following an interactive spreading activation model such as Dell, Juliano, & Govindjee, 1993; Plaut, McClelland, Seidenberg, & Patterson, 1996). During a TOT state, the connection weights are adjusted to represent the partial or incomplete pattern of activation between these two levels of representation. These adjustments likely occur through a Hebbian learning mechanism, through which connection weights are adjusted, making it slightly more likely that the same input in the future will again lead to that particular outcome (Hebb, 1949). This error learning manifests itself the next time the individual attempts retrieval of that word, when the adjusted weights re-instate the incomplete pattern of activation, thus resulting in a TOT state. In support of this interpretation, Warriner and Humphreys examined the parameters of the likelihoods of accessing the lemma and accessing the phonological form, which can be

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