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## RESOLVING TIP-OF-THE-TONGUE STATES WITH SYLLABLE CUES

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### Abstract

Tip-of-the-tongue (TOT) states represent a speaker's temporary and typically frustrating inability to retrieve a known word. Although TOTs are a type of failed word retrieval, they are useful for understanding the processes that underlie successful speech production. Specifically, TOT states are thought to result from weakened connections between a word's lexical representation (lemma) and its phonology (lexeme), a hypothesis supported by research showing that encountering phonologically-related cues during a TOT, specifically words containing the first syllable, helps to resolve the TOT. The chapter begins with a discussion of models of speech production, the locus of TOT states within these models, and various methodologies for investigating TOT states in laboratory studies. We then review previous research on syllable cueing of TOT resolution and present findings from a new experiment using a syllable in isolation as the cue. The chapter concludes by discussing the implications of these findings, including the theoretical significance of the syllable in resolving TOTs.

**Keywords:** tip-of-the-tongue (TOT), syllable, phonological cue, models of speech production

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## **1. Theoretical background**

### **1.1 The tip-of-the-tongue phenomenon as a breakdown in phonological encoding**

The tip-of-the-tongue (TOT) phenomenon is a word finding problem, a common and universal experience when a speaker cannot immediately recall a well-known or familiar word but has the certitude that the information exists in one's knowledge base. TOTs are reported to occur about once a week in everyday life and on 10-20% of items in laboratory studies (Brown, 2012, p. 195). TOTs are an important source of information concerning the nature of the processes and architecture of the speech production system (James & Burke, 2000, p. 1378). TOTs show us what happens when lexical retrieval fails. Models of speech production largely agree that the retrieval of a word first requires the activation of a concept to be expressed, followed by access to its semantic and syntactic properties (lemma), and lastly the activation of its phonological components (lexeme) (Dell, 1986; Dell, Chang, & Griffin, 1999; Dell & O'Seaghdha, 1991, 1992; Garrett, 1975, 1990; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Peterson & Savoy, 1998; but see Caramazza, 1997, for a model without the existence of a lemma level).

In the absence of successful retrieval, various aspects of the inaccessible target word are still frequently available in a TOT state: Speakers have a strong feeling of knowing the word, have access to semantic and sometimes syntactic information, and often have partial access to its phonological properties. For example, the speaker might have access to the word's syntax, in particular the grammatical gender of a noun (for gender-marking languages). This prediction was demonstrated with an Italian amnic patient called Dante, who could hardly name any pictures but knew in 95% - 98% of the cases the correct gender of the target name (Caramazza & Miozzo, 1997). Similar results have been reported with healthy, native Italian speakers (Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997). Although speakers cannot retrieve the complete phonological form of the target word, they are often able to retrieve the first phoneme or letter, the first syllable and number of syllables, other letters or phonemes, and also the stress pattern of the target word (Brown & McNeill, 1966; for a replication of Brown & McNeill in German, see Hofferberth, 2011). TOTs provide evidence for the existence of distinct stages in retrieving a word's lemma and lexeme during speech production: they demonstrate a breakdown between these two processes (Levelt, 1989).

While models of speech production largely agree on the general distinction between semantic-syntactic (lemma) and word form (lexeme) retrieval processes, they differ with regard to the precise architecture of the system.<sup>2</sup> According to the modular or *discrete-serial model* (Levelt, 1989; Levelt et al., 1999), the speech production process is staged: Phonological encoding starts after lemma selection is completed, i.e., after the final lexical candidate has been selected. The activation is unidirectional, i.e., the lexeme cannot intervene in the lemma activation process. Levelt's model was revised and updated ten years later (Levelt et al., 1999) and now allows multiple lemma selection in the case of near-synonyms (as a reaction to Peterson & Savoy, 1998, see below). Furthermore, a mental syllabary, which is a repository of frequently used phonetic syllables, was added to the model. Statistics show that native speakers of English or Dutch perform 80% of their oral production with no more than about 500 different syllables, although these languages have more than 10,000 different syllables. The syllabary repositis such overused, high-frequency syllabic gestures and allows fast retrieval of ready-made motor programmes for these syllables. In contrast, low-frequency syllables are formed online according to the segmental and metrical rules of the language. The advantage of a syllabary is that it reduces the programming load relative to segment-by-segment composition of phonetic forms, in particular because the syllables of a language differ greatly in frequency (Levelt et al., 1999, p. 32).

The *cascade model* of lexical access by Peterson and Savoy (1998) similarly proposes unidirectional activation, but allows for phonological encoding to begin before completing lemma selection under some circumstances. Peterson and Savoy (1998) as well as Jescheniak and Schriefers (1998) presented evidence showing that in the case of near-synonymy (e.g., a picture of a sofa/couch), both the eventually produced name of the picture (e.g., *couch*) as well as the near-synonym (e.g., *sofa*) are phonologically encoded, allowing the process of lexeme retrieval to be initiated before the lemma selection process has finished.

On the other hand, according to connectionist or so-called *interactive-activation models* (Dell, 1986; Dell et al., 1999; Dell & O'Seaghdha, 1991, 1992), there is bidirectional activation with a permanent interaction between the lemma and the lexeme level. As soon as the conceptual level

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<sup>2</sup> The terms *lemma* and *lexeme* were introduced by Kempen and Huijbers (1983) or rather Kempen and Hoenkamp (1987). In the model of Levelt et al. (1999), the lemma only enables access to the syntactic information while the semantic information is stored in so-called lexical concepts (Hantsch, 2002, p. 12). The term *lexeme* is used in this paper synonymously with word form.

has been activated, lemmas whose conceptual specifications match the conceptual structure become activated and spread activation to their corresponding lexemes. As a result, even lemmas that partly match the conceptual structures in the pre-verbal message will activate its phonological representation to some extent. Unlike stage models, activation can feed back from the lexeme to the lemma level. This potential for feedback activation has been critical for challenging discrete-serial models' inability to explain various phenomena, such as the statistical overrepresentation of mixed errors. When a speaker produces a mixed error, he/she replaces the intended word with a semantically and phonologically related word (e.g., *rat* instead of *cat*). Semantically and phonologically related words receive a combination of feedforward activation from the conceptual level and feedback activation from the phonological level. Therefore, *rat* (instead of *cat*, semantically and phonologically related) will be more strongly activated than *dog* (semantically related) or *mat* (phonologically related). Therefore, the chance to produce a mixed error is higher than that of producing a semantic or phonological error (Leuninger 1993, 1996).

## 1.2 Etiology

Despite differences between the speech production models described above, the locus of TOTs is similar. A lexical node in the semantic system (lemma) becomes activated, but there is insufficient activation transmitted to its associated phonological nodes (lexeme) to enable the word's retrieval. What causes this breakdown between lemma and lexeme retrieval? Two main hypotheses have been suggested: (1) The blocking hypothesis, where TOT states result from the presence of interlopers (Jones, 1987; Jones & Langford, 1987), and (2) the incomplete activation hypothesis, where TOTs result from insufficient activation of the to-be-retrieved word (Meyer & Bock, 1992). In the blocking hypothesis, another word can come to mind that prevents the intended word from being retrieved, resulting in a TOT. Interlopers can result from partial phonological information that is shared between the target and another word, creating competition. For example, given the cue *Aida Composer*, participants may recover the initial letter *V*, the final letter *I*, and know that it is a short Italian name and could then recall *Vivaldi* instead of *Verdi* (Maril, Wagner, & Schacter, 2001, p. 658).

One type of incomplete activation hypothesis is the transmission deficit hypothesis (TDH; Burke, MacKay, Worthley, & Wade, 1991; MacKay & Burke, 1990), a corollary of node structure theory (MacKay,

1987), which arranges nodes (conceptual representations) into a hierarchical network of multilevel systems, including semantic, syntactic, and phonological systems. Activation of nodes (and subsequent retrieval of the information it contains) is dependent on the most-primed-wins principle: When nodes in the same level receive simultaneous priming, only the node receiving the most priming can be activated. The TDH defines the locus of incomplete activation as a failure to fully transmit activation from the lexical to the phonological nodes as a result of weakened connections between these nodes. The frequent availability of partial target word information in a TOT state supports this view. Connections are thought to weaken as a function of frequency of use (words not used frequently are more susceptible to TOTs), recency of use (less recently-used words are more likely to have TOTs), and the normal aging process (more TOTs occur with increasing age).

### 1.3 Eliciting and measuring TOTs

In the 1930s, Wenzl (1932; 1936) and Woodworth (1934) collected naturally-occurring TOTs in diary studies. About 30 years later, the first systematic laboratory study was undertaken by Brown and McNeill (1966). They read out definition-like questions of low-frequency words to elicit TOTs, and participants had to write down the information they could retrieve while experiencing a TOT. The results showed that participants often had access to partial information of the target word, such as letters in the word, the number of syllables, and words with similar sound and/or similar meaning. Brown and McNeill (1966) also found that the degree of orthographic overlap between words given by the participants and the targets was highest for the beginning of the word, intermediate for the ending, and lowest for the middle part, resulting in a U-shaped serial position function (p. 330f.). Furthermore, participants not only provided the initial letter of the target word but occasionally more than one letter, e.g., *ex* (for *extort*) or *con* (for *convene*). Brown and McNeill (1966) did not make reference to the significance of producing the first syllable in these cases, but they suggested that this could arise because “some letter (or phoneme) sequences are stored as single entries having been ‘chunked’ by long experience“ (p. 331).

Many studies attempt to induce TOTs by presenting a specific definition of a target word, such as “A navigational instrument used in measuring angular distances, especially the altitude of sun, moon, and stars at sea” for *sextant* (Brown & McNeill, 1966, p. 333). If participants are able to retrieve the target, they say it aloud or write it down. When

participants cannot retrieve the target, they are asked to indicate if they do not know the word or are having a TOT, where the difference between these responses is defined in terms of the imminence of recall (Brown & McNeill, 1966, p. 325). Ways of defining TOTs have varied dramatically across studies. Some researchers define TOTs as equivalent to long or extended retrieval, i.e., a word that does not come to mind immediately must be a TOT. For example, Hamberger and Seidel (2003) defined a TOT as taking at least two seconds, using Goodglass, Theurkauf, and Wingfield's (1984) assertion that normal retrieval consists of two stages: automatic (up to 1.5s) and effortful (after 1.5s). Vigliocco et al. (1997) defined TOTs in terms of the availability of partial information, where TOTs were only counted as such when participants could provide partial information.

One criticism of TOT research is that it is difficult to measure TOT states objectively. In most lab studies, TOTs are measured subjectively, i.e., a participant indicates having a TOT, and the experimenter has to assume that participants have accurate access to and reporting of their metacognitions. Furthermore, TOT incidence can be influenced by various factors unrelated to the words themselves, such as the wording of instructions. When participants are instructed that the target words are difficult ("95% of students had great difficulty answering them"), participants indicate DON'T KNOW more often than when the target words are indicated as easy ("95% of students had little difficulty answering them"), which increases participants' likelihood of reporting a TOT state (Harley & Bown, 1998). In some studies, clarifications are added to make sure that participants don't report a TOT simply because the target word is from a familiar area in which the word should be known (Ravizza, 2003).

It can be difficult to compare TOT studies because they do not use the same instructions or target words, and they also differ in the design. As noted above, it makes an immense difference how to define TOTs and what to count as a TOT. Furthermore, TOT incidence can vary broadly both across items and participants, and create a "fragmentary data problem" (Brown & McNeill, p. 328). In many studies, there are participants who never experience TOTs, which can result in a "hidden subject-selection bias" (Brown, 2012, p. 54) because participants who did not report any TOTs are excluded from the analyses. Similarly, a small number of words can be overrepresented in TOT analyses given that not all words elicit TOTs (Brown 2012, p. 54f.). Providing information about target words, their definitions, and TOT rate per target word can help other researchers. For example, Abrams, Trunk, and Margolin (2007) summarized

TOT incidence for 163 target words, collected in five experiments (Abrams, White, & Eitel, 2003; Abrams & Rodriguez, 2005; Robinson, Abrams, & Bahrick, 2004; White & Abrams, 2002).

### 1.4 TOT resolution

TOT resolution can be achieved through external search strategies (such as looking up the word online, in a dictionary, or by asking someone) or through internal strategies (such as mentally going through the alphabet or generating similar words). Laboratory studies often involve cueing procedures with a cue-target relationship that is not readily obvious, yet efficient to boost activation of the target word and assist TOT resolution. The terminology in the literature sometimes differs between the terms *primes* and *cues*. We use the term *cue* here as defined by Brown (2012), where “primes precede and cues follow the initiation of a target word search procedure” (p. 67). Cueing designs can be used to either manipulate TOT *incidence* (the probability of a TOT occurring) or influence TOT *resolution* (retrieving the intended word after reporting a TOT). Some studies have shown that phonologically-related cue words (in comparison to semantically-related cue words) increase TOT incidence, when the cue word was presented immediately after the definition (Jones, 1989; Jones & Langford, 1987; Maylor, 1990; but see Meyer & Bock, 1992; and Perfect & Hanley, 1992, for critiques on Jones’ stimuli). In contrast, the effect of phonological cues on TOT resolution is generally facilitatory. Phonological cues boost activation to the target words during TOTs relative to unrelated words (Abrams et al., 2003; Abrams & Rodriguez, 2005; Abrams, Trunk, & Merrill, 2007; Burke, MacKay, Worthley, & Wade, 1991; Farrell & Abrams, 2011; Harley & Bown 1998; Heine, Ober, & Shenaut, 1999; James & Burke 2000; Meyer & Bock, 1992; Rastle & Burke, 1996; White & Abrams, 2002).

A phonologically-related cue is defined differently in these studies in terms of the degree of phonological overlap, including phonological neighbours, orthographic or phonological syllables within cue words, overlapping initial sound and/or letter, and shared number of syllables or stress pattern. For example, the phonological cues used by Meyer and Bock (1992) were described as having “the same initial sound and letter, the same number of syllables, and the same stress pattern as did the corresponding targets but were unrelated to them in meaning” (p. 717). However, the items themselves varied widely, with some cues sharing only the initial sound and letter, while others shared the entire first syllable. Furthermore, while the majority of TOT studies did not control

the grammatical class of the cue, Abrams and Rodriguez (2005) demonstrated that the likelihood of phonological cues increasing TOT resolution depends on whether the target and cue shared grammatical class (see below). Thus, more precisely defining phonological cues will make it easier to compare findings across studies, and we focus on a definition where phonological overlap includes the initial syllable of the target word.

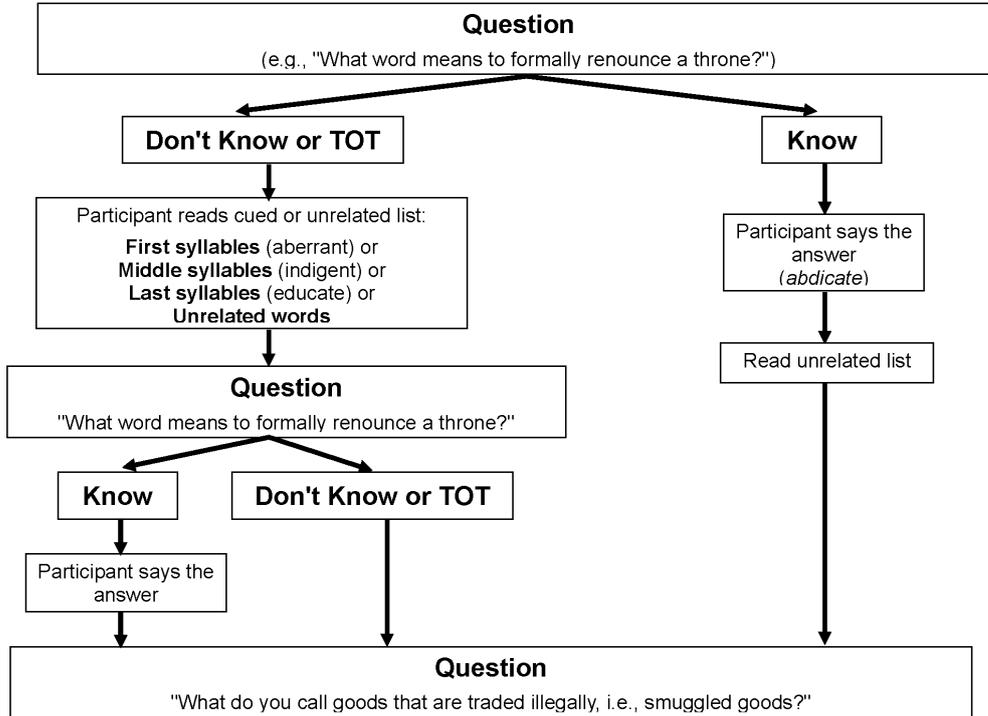
## 2. Cuing studies

### 2.1 Studies with syllable cues in word lists

The general methodology of these cueing studies involves presentation of general knowledge questions or definitions whose answers correspond to a target word. Participants are asked to indicate whether they know the target (and to produce it if so), do not know it, or are having a TOT. After TOT responses, a list of words is presented one at a time, where either all of the words are unrelated to the target, or some are phonologically related by containing specific syllables of the target word. Participants are asked to read each word and sometimes make some type of judgment about it. After the word list has been presented, the original TOT-inducing question is shown again to see if the target word can now be retrieved. Cueing is measured as the difference in TOT resolution following a list containing phonologically-related words relative to a list with solely unrelated words. Following all questions, a multiple-choice recognition test is given for unresolved TOT questions so that only "correct" TOTs, i.e., target words that participants correctly recognize, are included in analysis.

James and Burke (2000, Experiment 2) were the first to use syllables to cue TOT resolution, showing that both younger ( $M = 19$  years) and older adults ( $M = 72$  years) were more likely to resolve TOTs when phonologically-related words that cumulatively contained the target's syllables were presented during a TOT, relative to unrelated words. For example, when having a TOT for the target *abdicate*, reading a list that contained the words *indigent*, *abstract*, *truncate*, *tradition*, and *locate* (syllables italicized here for emphasis) increased TOT resolution. White and Abrams (2002; see also Abrams et al., 2003, Experiment 2) further highlighted the significance of the syllable unit by showing that the locus of phonological cueing effects on TOT resolution is the target's first syllable. Using a list where three of the words contained only one of the target's syllables, either the first (*ab*), middle (*di*), or last syllable (*cate*), they found that both younger ( $M = 20$  years) and young-old adults ( $M = 67$  years) experienced greater TOT resolution following lists containing first-

Figure 1. Experimental procedure used in White and Abrams (2002).



syllable cues than unrelated lists, whereas resolution was unaffected by middle- and last-syllable cues.<sup>3</sup> See Figure 1 for an illustration of the procedure. An even older group, old-old adults,  $M = 77$ , did not show first-syllable cueing. Abrams et al. (2003) demonstrated that the benefits to younger adults' TOT resolution were unique to a full first syllable, as cues containing the target's initial letter or initial phoneme (but not syllable) had no effect on TOT resolution.

Abrams and Rodriguez (2005; see also Abrams, Trunk, & Merrill, 2007) qualified the previously demonstrated first-syllable cueing effect on TOT resolution in younger adults by illustrating the relevance of a phonological cue's grammatical class. Targets (e.g., *rosary*, a noun) were cued with a list, where one of the words contained the target's first syllable and either shared (*robot*, a noun) or did not share the target's grammatical class (*robust*, an adjective). TOT resolution was increased following lists containing a phonological cue in a different grammatical class relative to a list of unrelated words, replicating previous findings of a first-syllable cueing effect. However, phonologically-related cues in the same grammatical class had no effect on TOT resolution. Abrams et al. (2007) replicated these findings and extended the finding of first-syllable cueing on TOT resolution to young-old adults ( $M = 69$  years), who showed slightly reduced first-syllable cueing from phonological cues in a different grammatical class compared to younger adults. In contrast, old-old adults ( $M = 80$  years) did not show significant first-syllable cueing from phonological cues in a different grammatical class and instead showed an inhibitory effect on TOT resolution following cues in the same grammatical class.

Together, these findings support models of speech production where phonologically-related words transmit activation to the weakened phonological representations that are thought to cause TOTs, increasing the likelihood of retrieving the target. Access to the initial syllable is necessary for TOT resolution to occur, as the initial phoneme does not transmit sufficient activation to enable target retrieval. However, several variables, specifically grammatical class and aging, mediate the relationship between phonological cueing and resolution of TOT states. Grammatical class functions to activate appropriate candidates for production, and phonological cues can only facilitate TOT resolution when the cue itself is not a potential competitor for retrieval. The normal aging process exacerbates the weakening of phonological representations so that

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<sup>3</sup> Word lists were also shown after DON'T KNOW and KNOW responses to minimize participants' awareness of the relation between the phonological cues and targets.

cues that help to resolve TOTs at earlier ages do not help (and can even hurt retrieval) in the later stages of aging, suggesting that additional phonological input may be necessary to resolve TOTs as we age.

## **2.2 Studies with syllable cues in pseudowords**

Pseudoword cues offer a vehicle for presenting a TOT target's first syllable in the appropriate position independent of embedding that phonology in an existing lexical representation. Abrams, White, Merrill, and Hausler (2007) investigated whether phonological pseudoword cues, defined as multisyllabic, pronounceable strings of letters that were not real English words and contained the target's first syllable, could help to resolve TOT states. Cues were presented auditorily among a list containing three words and three pseudowords, to which participants made a lexical decision judgment (said 'yes' or 'no' as to whether the item was a real English word). In Experiment 1, phonological cues were assigned a suffix unassociated with a specific grammatical class. The results showed significant first-syllable cueing, where TOT resolution following lists with a phonologically-related pseudoword was greater than resolution following lists containing an unrelated pseudoword. In Experiment 2, phonological cues were given a suffix that was commonly associated with a particular grammatical class, which was either the same as or different from the target's part of speech. As seen previously with word cues, the results showed that more TOTs were resolved following a pseudoword cue in a different grammatical class relative to an unrelated pseudoword, demonstrating significant cueing of TOT resolution. In contrast, TOT resolution following a pseudoword cue in the same grammatical class and an unrelated pseudoword was equivalent.

Pureza, Soares, and Comesana (2012) elicited TOTs in European Portuguese speakers using a picture naming task, after which a list of 14 words and pseudowords were visually presented for lexical decisions. Four of the pseudowords were pseudohomophone cues, containing either the first syllable, last syllable, or no syllable of the target word in order to manipulate the syllabic position. After the lexical decision task, the TOT-inducing picture was shown again, and resolution was assessed. Although a different methodology from previous studies, the results demonstrated a significant syllabic pseudohomophone cueing effect on TOT resolution. Following TOT responses, seeing pseudohomophone cues increased target retrieval, especially for longer words (four-syllable words in comparison to two- and three-syllable words). The authors also report a posteriori analysis, which "seems to show that the positional syllable frequency has

an effect especially for the first position” (p. 13), as was found by White and Abrams (2002) and Abrams et al. (2003).

These results with pseudoword phonological cues demonstrate that while encountering the initial syllable during a TOT is essential to resolving the TOT as shown in previous research, the syllable does not need to be embedded within a real word. When pseudowords possess sufficient phonological and appropriate grammatical information, they are able to influence the subsequent activation of the target’s phonology for resolving TOTs, suggesting that the basis of phonological cueing of TOT resolution at least begins from sublexical components. Furthermore, first-syllable phonological cueing of TOT resolution is not limited to English, showing that it also occurs in languages with well-defined syllable boundaries, such as European Portuguese.

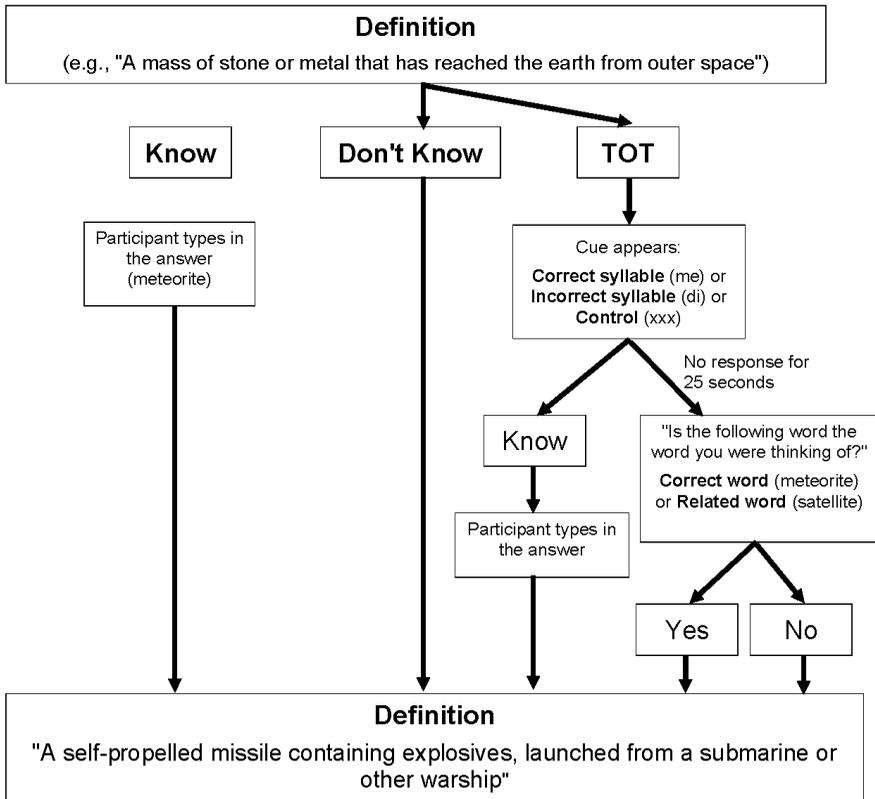
### **2.3 Studies with syllable cues presented individually**

In this chapter, we present new data using a reaction-time (RT) experiment to determine whether the correct first syllable of the target word facilitates TOT resolution and whether a first syllable different from the target’s first syllable but with matched frequency inhibits TOT resolution (Hofferberth-Sauer, in preparation). In contrast to the studies of Abrams et al. (2003), the cue consisted only of the first syllable alone and was not embedded within a word that shared the same first syllable as the target. Furthermore, RTs, which have to our knowledge never previously been reported in TOT research with phonological cueing, allow for a more objective measure of TOTs, one that is not dependent on participants’ self-report. Forty-eight under- and postgraduates between 21 and 35 years (30 female, 18 male,  $M = 29.5$  years,  $SD = 3.7$ ) from Heinrich-Heine-University Dusseldorf participated in this study. They were native speakers of German and were paid for their services.

#### **2.3.1. Procedure**

The definitions (in German) were presented on a computer screen using the program *Presentation*. The definitions were selected from two pilot studies that were conducted to determine the definitions that induced more TOT states and had a higher rate of name agreement, in order to minimize the occurrence of TOTs for a word different from the intended target (Hofferberth, 2012). Out of a pool of 353 definitions, 240 definitions were presented to induce TOTs. The frequencies of the German target words as well as the frequencies of the first syllables of these nouns were taken from

Figure 2. Experimental procedure used in Hofferberth (2012). While the experiment was conducted in German, an example translated into English is shown here for illustration purposes and for easier comparison with other experiments conducted in English.



the DLEX database. The frequencies of the syllables were needed in order to match the correct and incorrect syllables. The correct syllable is the one that fits the target word, whereas the incorrect syllable was taken from another target word in the experiment with matched frequency.

Participants read definitions on a computer screen and pushed a button to indicate KNOW, DON'T KNOW or, TOT, respectively. When in a TOT state, a written cue was presented for 25 seconds that was either the correct first syllable of the target word, an incorrect syllable with matched frequency as the fitting syllable, or a neutral baseline condition consisting

of a row of Xs, "xxx". The experimental procedure is illustrated in Figure 2. For example, the definition for the target *meteorite* was "A mass of stone or metal that has reached the earth from outer space". When the participant indicated to be in a TOT state, the correct first syllable *me*, the incorrect first syllable *sa*, or the control condition xxx appeared on the screen. If the TOT state was not resolved within 25 seconds, a question appeared on the screen as a general manipulation check to assess whether participants were correctly reporting TOTs. Participants were asked "Is the following word the word you were looking for?", together with a word that was the target word 50% of the time and a word semantically but not phonologically related to the target word the other 50% of the time. No participant answered the question incorrectly (incorrect endorsement and incorrect rejection) more than 60% of the time ( $M = 48.2\%$ ,  $SD = 11.7\%$ ).

### 2.3.2. Results

#### 2.3.2.1 Reaction Times

The RTs differed between KNOW, DON'T KNOW, and TOT,  $F(2, 94) = 41.9$ ,  $p < .001$ , as seen in Figure 3. The RTs to report KNOW ( $M = 5265$  ms,  $SD = 1085$  ms) were faster than DON'T KNOW responses ( $M = 5923$  ms,  $SD = 1311$  ms),  $t(47) = 4.49$ ,  $p < .01$ , which in turn were faster than TOT responses ( $M = 6474$  ms,  $SD = 1122$  ms),  $t(47) = 4.34$ ,  $p < .01$ . With respect to the influence of a cue, RTs to report KNOW after the presentation of one of the cues in the TOT state were faster with the correct cue ( $M = 4055$  ms,  $SD = 1689$  ms) in comparison to the incorrect cue ( $M = 7807$  ms,  $SD = 3984$  ms),  $t(47) = 6.92$ ,  $p < .01$ , or the control condition ( $M = 7559$  ms,  $SD = 2582$  ms),  $t(46) = 10.42$ ,  $p < .01$ , with no difference between the latter two conditions,  $t(46) = .40$ ,  $p = .69$ .

#### 2.3.2.2 TOT Incidence and Resolution Rates

The TOT rate was 20.2% (= 2,326 TOTs out of overall 11,520 stimuli). After the cue was presented, 862 (37.1%) were accurately resolved TOTs where the answer was consistent with the target word, 354 (15.2%) were inaccurately resolved TOTs where the answer differed from the target word, and 1,110 (47.7%) of the TOTs remained unresolved after 25 seconds.

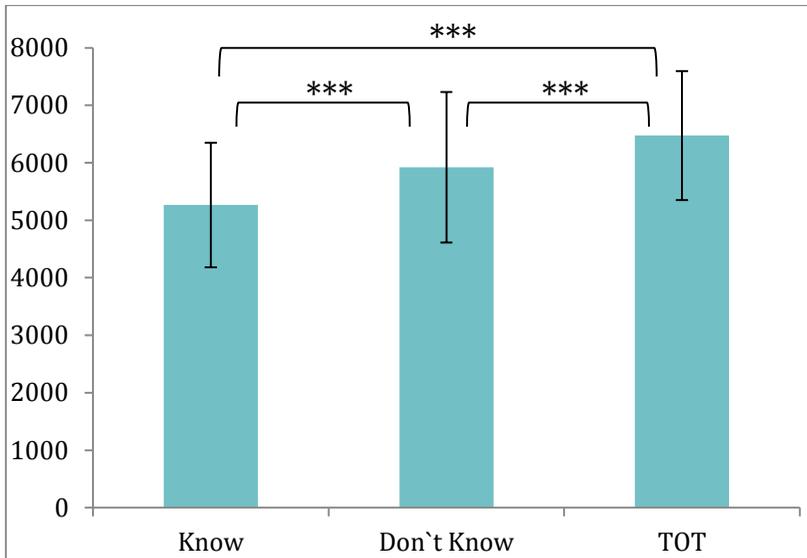


Figure 3. Reaction times to definition.

X-axis: Response type, y-axis: Mean RTs (in ms).

Error bars represent  $\pm 1$  SD; \*\*\* =  $p < .001$

### 2.3.2.3 Effects of Cue on TOT Resolution<sup>4</sup>

The number of *accurate TOT resolutions* differed between the three types of cues,  $F(2, 94) = 260.6$ ,  $p < .001$ . When given the correct first syllable, TOTs were accurately resolved more often ( $M = 73.5\%$ ,  $SD = 18.6\%$ ) in comparison to the control condition ( $M = 24.3\%$ ,  $SD = 16.4\%$ ),  $t(47) = 16.4$ ,  $p < .001$ , which had more resolved TOTs than an incorrect syllable ( $M = 16.0\%$ ,  $SD = 13.6\%$ ),  $t(47) = 3.7$ ,  $p = .001$  (see Figure 4).

<sup>4</sup> The items on which participants experienced TOTs could not be determined ahead of time. So, the number of TOTs per person differed, and it was impossible to give each participant an equal number of the three cue types (correct syllable, incorrect syllable, no cue). To adjust for these differing numbers of cues, a percentage of TOT resolution was computed per participant, where the number of resolutions was divided by the number of TOTs that occurred in each cue condition.

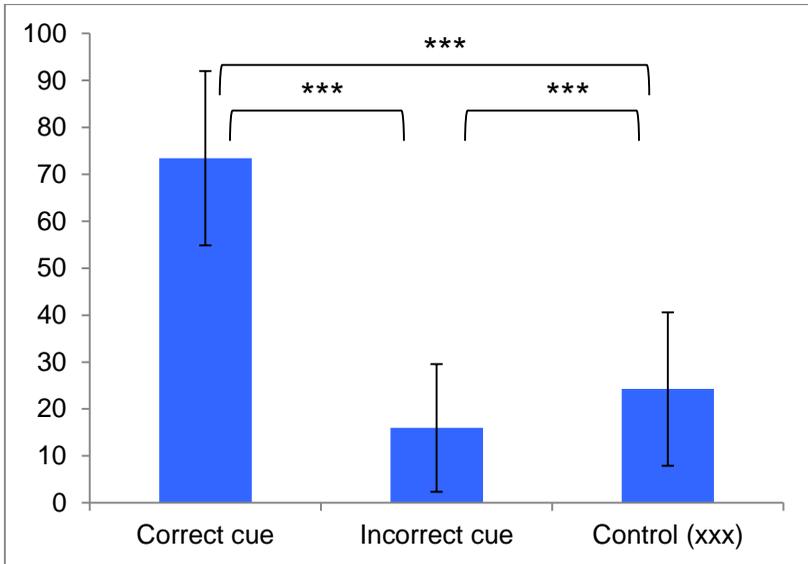


Figure 4. Accurate TOT resolutions.

X-axis: Cue type, y-axis: Mean accurate TOT resolution (in %)

Error bars represent  $\pm 1$  SD; \*\*\* =  $p < .001$

The number of *inaccurate TOT resolutions* also differed between the three types of cues,  $F(2, 94) = 17.6$ ,  $p < .001$ . Fewer TOTs were inaccurately resolved when given the correct first syllable ( $M = 9.2\%$ ,  $SD = 7.8\%$ ) in comparison to an incorrect syllable ( $M = 15.8\%$ ,  $SD = 14.4\%$ ),  $t(47) = 3.6$ ,  $p = .001$ , which in turn had fewer inaccurate TOT resolutions than the control condition ( $M = 20.2\%$ ,  $SD = 14.4\%$ ),  $t(47) = 2.4$ ,  $p = .023$  (see Figure 5).

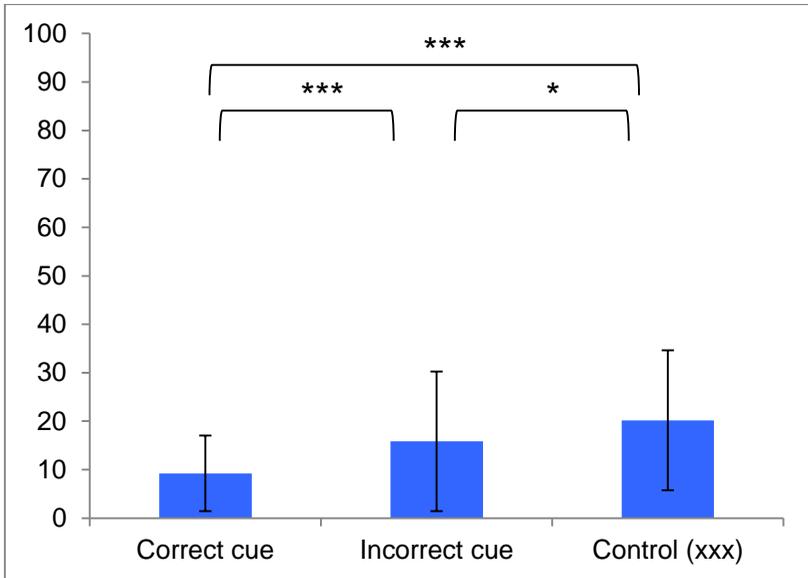


Figure 5. Inaccurate TOT resolutions.

X-axis: Cue type, y-axis: Mean inaccurate TOT resolution (in %)

Error bars represent  $\pm 1$  SD; \*\*\* =  $p < .001$ , \* =  $p < .05$

The number of *unresolved TOTs* also differed between the three types of cues,  $F(2, 94) = 152.3$ ,  $p < .001$ . There were fewer unresolved TOTs after the correct first syllable ( $M = 17.3\%$ ,  $SD = 16.9\%$ ) in comparison to the control condition ( $M = 55.6\%$ ,  $SD = 20.2\%$ ),  $t(47) = 12.3$ ,  $p < .001$ , which had fewer unresolved TOTs than an incorrect syllable ( $M = 68.2\%$ ,  $SD = 20.4\%$ ),  $t(47) = 4.6$ ,  $p < .001$  (see Figure 6).

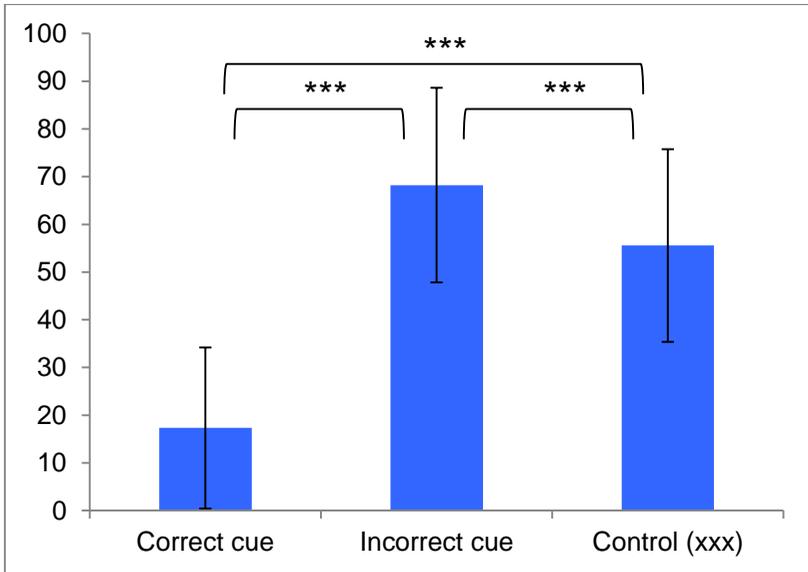


Figure 6. Unresolved TOTs.

X-axis: Cue type, y-axis: Mean unresolved TOTs (in %).

Error bars represent  $\pm 1$  SD; \*\*\* =  $p < .001$

### 2.3.3 Summary

These findings extend previous research on TOT resolution in several ways. First, they conclusively demonstrate the importance of the first syllable in resolving TOTs, as the syllable itself was the sole cue rather than a cue where the syllable was embedded in another word or pseudoword. Second, the recording of RTs to categorize one's retrieval experience illustrates that the ease and speed with which information comes to mind is hampered in a TOT state: It takes more time to report a TOT than either KNOW or DON'T KNOW responses. Third, these results demonstrate the benefits of the correct syllable on TOT resolution not only in terms of increased target retrieval, but also in terms of RT to indicate the target word was now known. When given the correct first syllable of a target word during a TOT state, TOTs were successfully resolved approximately 4.6 times more often in comparison to an incorrect syllable and about 3 times more often compared to the control condition. Correct syllables also reliably facilitated TOT resolution by increasing accurate retrievals of the target word and decreasing inaccurate retrievals of some

other word. Furthermore, participants responded approximately twice as fast to resolve the TOT when given the correct syllable in comparison to an incorrect syllable or the control condition. Lastly, the present findings report a rarely-observed inhibitory effect on TOT resolution, where an incorrect syllable actually inhibited TOT resolution by decreasing accurate retrievals and increasing unresolved TOTs, although it is worth noting that an incorrect syllable did not increase inaccurate retrievals of the wrong word. In fact, there were more inaccurate TOT resolutions following the control condition than an incorrect syllable. More generally, these results indicate that the presentation of the correct first syllable of the target word strengthens the weakened phonological connections that cause TOTs and facilitates word retrieval. These results support the TDH, which claims TOTs occur when activation fails to be fully transmitted from the lexical to the phonological nodes.

### 3. General Discussion

Together, these studies have demonstrated the significance of the first syllable in cueing TOT resolution. The experiments from James and Burke (2000) demonstrated that the presentation of cue words cumulatively containing the first, middle, and last syllable of the target word facilitated TOT resolution. Abrams and colleagues (White & Abrams, 2002; Abrams et al., 2003) were the first to demonstrate the importance of the initial syllable, showing that the first syllable was the only cue that increased TOT resolution in comparison to the middle or last syllable (Experiment 2) and the first phoneme or first letter (Experiments 1 and 3). Subsequent research has shown that the syllable itself is key, independent of its embedding within a phonological cue word, evidenced by its boosting of TOT resolution when presented within a pseudoword cue (Abrams et al., 2007), a pseudohomophone cue (Pureza et al., 2012), or by itself (Hofferberth-Sauer, in preparation).

These findings support speech production models' assumption that the cause of TOT states is a breakdown in phonological encoding, i.e., a failure in the transmission of activation from the lexical to the phonological level. Providing the first syllable overcomes this deficit in activation, increasing TOT resolution, but in different ways depending on the model. In interactive activation models, presenting the first syllable during a TOT state provides a sufficient boost in activation to the target via two sources: feed-forward activation from the target's semantic representation and feedback activation from the syllable's phonological form, which strengthen the weakened phonological connections and

resolve the TOT. Within the model of Levelt et al. (1999), there is a so-called *feedback loop* through the perceptual network that sends the partial information of the TOT word to the conceptual system, where the lemmas of phonologically-related words receive activation. The corresponding morpheme representations get activated, which in turn activate the corresponding syllable programme nodes. The loop permits that the syllable programmes that fit the TOT word get selected, thus facilitating TOT resolution and production of the target word (see also Roelofs, 2003). However, other findings showing that phonological cueing of TOT resolution is dependent on other factors is problematic for a stage model. Abrams and Rodriguez (2005) showed that the grammatical class influences TOT resolution, i.e., the first syllable of the target word embedded in a cue word (lexeme) only facilitated TOT resolution when the cue had a different syntactic class (lemma information) as the target word. Grammatical class is part of the syntactic information that is stored in the lemma. Therefore, the finding that phonological cueing is dependent on the lemma's grammatical class suggests interactivity between the lemma and lexeme levels, which is not allowed by discrete serial models. Furthermore, it is not specified how a lemma's grammatical class would interface with the feedback loop and result in differential TOT resolution as a function of grammatical class.

Farrell and Abrams (2011) showed that first syllable frequency also interacted with phonological cueing of TOT resolution. During TOT states, a cue with the same first syllable as the target word was presented, and this syllable was designated as either high or low in syllable frequency. Young ( $M = 19.5$  years), young-old ( $M = 68.4$  years), and old-old adults ( $M = 79.5$  years) all demonstrated an inhibitory effect of syllable frequency on TOT resolution, where more TOT states were resolved following cues beginning with low-frequency syllables than high-frequency syllables. According to the mental syllabary model, high frequency syllable words should be produced more efficiently and resolve more TOTs, not fewer TOTs, than low frequency syllable words because of the automatic retrieval of the motor programmes for high-frequency syllables.

In general, the consistency of syllable cues in facilitating TOT resolution is striking given the methodological differences across studies. One such difference involves the mode of participants responding. For example, in the experiments of Abrams and colleagues, participants verbally gave their responses, and the experimenter typed in all of the responses into the computer. This methodology was employed because several experiments were conducted with both young and older adults, and

having the experimenter type all responses minimized any potential differences that might have arisen from older adults having less familiarity with computers. Hofferberth's experiments were designed solely for young adult participants, and consequently participants typed in their own responses, allowing reaction times to be measured. Contrary to many speech production tasks where reaction times are the measure of interest (e.g., picture naming), the use of reaction times to investigate TOT resolution is a new method in TOT research and should be used in future studies to make TOT categorization more objective.

Another methodological difference involves whether cues were presented solely after TOT responses. In Abrams' studies, the list containing the cue was presented after both TOT and DON'T KNOW responses (and a list of unrelated words was presented following KNOW responses). The logic of this procedure was to ensure that the TOT resolution process remained automatic. By presenting word lists after all responses, participants would be less likely to become aware of the phonological relationship between the cues and target words and subsequently less likely to use a strategy where they intentionally used the cues to help them retrieve the target. This procedure also demonstrated that phonological cueing was unique to TOTs, as having cues did not increase target retrieval following DON'T KNOW responses. In Hofferberth's experiments, the cue was only presented after participants reported being in a TOT state. The advantage of this procedure is that more definitions could be presented and cued with the time saved by not showing cues after DON'T KNOW responses. Whereas approximately 75 - 100 definitions per participant were used in the Abrams' studies (which took participants 1 - 1.5 hours to complete), 240 definitions were tested in Hofferberth's experiments in the same amount of time, which is useful for increasing the TOT rate, an issue that is directly related to the statistical power of analyses.

Regardless of which methodology is used, all studies should have some way of verifying which TOTs were correct (i.e., the word in mind was the intended target word) versus incorrect (i.e., a different word was being thought of). When TOTs are resolved, it is easy to determine whether participants were thinking of the correct word or not when they initially said TOT. It is less clear whether the TOT is correct when it remains unresolved. Abrams and collaborators addressed this issue by using a multiple-choice recognition test after all questions had been presented. If participants were able to correctly *recognise* the target word for TOT responses that remained unresolved, these TOTs were considered to be correct, adding validation to participants' initial self-report of having

a TOT. In contrast, Hofferberth's experiments relied on *retrieved* words to assess the correctness of TOTs, which leaves undetermined whether the unresolved TOTs were correct TOTs or TOTs for another word different from the target.

The aim and scope of this paper was to show that the syllable plays an important role in word finding failures. The syllable as a phonological cue increases TOT resolution in spite of the various ways of using the syllable as a cue, the methodologies for inducing and measuring TOT resolution, and even the languages of the stimuli, an impressive regularity given that the role of the syllable is quite different across languages. Furthermore, even though TOTs represent a failure of spoken language production, they can be cued with written as well as auditory materials, representing the universality with which we encounter phonology in everyday life. Understanding the ways in which the syllable contributes to TOT incidence and resolution, in addition to successful speech production, should play an important role in future research and help us to refine current models of speech production.

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