

**The Tip-of-the-Mandarin Tongue: Phonological and Orthographic Priming of TOT
Resolution in Mandarin Speakers**

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Abstract

Studies of tip-of-the-tongue (TOT) experiences in English have shown that priming the TOT's first syllable, especially a low-frequency one, helps to resolve the TOT. We explored whether priming of TOT resolution occurs in Mandarin, a language whose visual representation (orthography) is largely independent of sound (phonology). Participants saw descriptions corresponding to cheng-yu targets, four-character Chinese idioms. After a TOT, they saw a list of words where one was sometimes a phonological (Experiment 1) or orthographic (Experiment 2) prime. Phonological primes had a first character different from the target's but contained either its first syllable or first phoneme, whereas orthographic primes contained the target's first radical. Results showed that two factors marginally increased TOT resolution: first syllable primes and higher-frequency first radicals. These results are discussed in terms of a transmission deficit model of TOTs in Mandarin where priming of TOT resolution has both similarities and differences with alphabetic languages.

Keywords: tip-of-the-tongue (TOT), Mandarin, phonological and orthographic priming, syllable and radical frequency; idioms

The Tip-of-the-Mandarin Tongue: Phonological and Orthographic Priming of TOT Resolution in Mandarin Speakers

The tip-of-the-tongue (TOT) phenomenon, an inability to recall a word despite having a sensation of knowing the word (Brown & McNeill, 1966), has been documented across a variety of spoken and signed languages (Borodkin et al., 2007; Ecke, 1996; Gollan & Silverberg, 2001; Ouyang et al., 2020; Pureza et al., 2013; Shin, 2019; Thompson et al., 2005; Vigliocco et al., 1997). However, with respect to factors that help to *resolve* TOTs, the majority of previous research has primarily studied English speakers. One factor shown to influence TOT resolution in English is phonological priming, where encountering words during a TOT that are phonologically related to the target word increases resolution (James & Burke, 2000), specifically a word that contains the target word's first syllable (Abrams & Rodriguez, 2005; Abrams et al., 2003). Phonological priming of TOT resolution is also affected by the prime's first syllable frequency, where TOTs primed with words with low-frequency first syllables are more likely to be resolved than those with high-frequency first syllables (Farrell & Abrams, 2011). While these findings suggest a critical role for a word's first syllable in facilitating its retrieval, it is unknown whether this conclusion extends to a language like Mandarin which has distinct phonological and orthographic properties. The present experiments investigated the effect of (a) phonological factors, i.e., first syllable priming and syllable frequency, and (b) orthographic factors, i.e., first radical priming and radical frequency, on the resolution of Mandarin TOTs.

Phonological Locus of TOTs

Within theories of speech production, TOTs are thought to result from unsuccessful phonological encoding of the selected lemma (e.g., Dell, 1986; Levelt, 1989). A detailed

explanation comes from the Transmission Deficit model (e.g., Burke et al., 1991; MacKay & Burke, 1990), which embeds TOTs in the context of an interconnected mental network of nodes. Nodes are hierarchically organised into semantic (meaning-based), syntactic (grammar-based), orthographic (writing-based), and phonological (sound-based) systems that interact with one another. The connections between a word's lexical node and its phonological nodes are critical for successful speech production. Furthermore, activation of phonological nodes occurs in a left-to-right sequence such that a speaker must activate the first phonological node of a word before the second node can be activated, and so forth (MacKay, 1987). Within the Transmission Deficit model (MacKay & Burke, 1990), TOTs occur when the connections between a lexical node and its phonological nodes are weakened, which reduces the efficacy of transmitting node priming (hereafter called activation) across those connections. This reduces the likelihood that all of the phonological nodes will be retrieved and consequently result in a TOT. If some of the phonological nodes receive sufficient activation, a speaker in a TOT might recall the first phoneme or other partial phonological information of a word but not the word in its entirety (Brown & McNeill, 1966; Koriat & Lieblich, 1974).

Empirical support for this phonological locus of TOTs comes from studies showing that strengthening the weakened phonological connections, i.e., through presentation of words phonologically related to the TOT, increases TOT resolution (James & Burke, 2000). Abrams et al. (2003) demonstrated that the English first syllable was uniquely critical for priming TOT resolution, whereas primes containing the TOT's first phoneme, middle syllable, or last syllable had no effect. Studies in other alphabetic languages have also demonstrated the importance of the first syllable in TOT retrieval (Hofferberth-Sauer & Abrams, 2014; Pureza et al., 2013). Using syllables as primes rather than entire words, Hofferberth-Sauer and Abrams (2014) found

that the first syllable created a facilitatory effect on TOT resolution in German speakers. Participants resolved TOT states more often and more quickly when given the correct first syllable relative to an incorrect syllable or a control condition consisting of a row of Xs. Pureza et al. (2013) found that priming the first syllable facilitated TOT resolution in European Portuguese speakers but also found a priming benefit from last-syllable primes. The authors acknowledged that priming from the last syllable might reflect cross-linguistic differences, e.g., European Portuguese has well-specified syllable boundaries in contrast to English, and we propose that structural differences like these may influence the degree to which phonological primes can strengthen weakened connections and influence TOT resolution.

Other studies have found that the first syllable priming effect on TOT resolution is modulated by syllable frequency, the rate at which a particular syllable occurs in a certain language. When English speakers in TOT states were primed with the first syllable of the word, they resolved more TOTs when that syllable had a lower frequency than a higher frequency (Farrell & Abrams, 2011). A similar effect of first syllable frequency was reported in European Portuguese TOT resolution (Pureza et al., 2013). Within the Transmission Deficit model, these first syllable frequency effects can be explained by the number of lexical nodes that connect to a syllable node. A lower-frequency first syllable connects to relatively few lexical nodes, making it easier to strengthen the connection between that syllable and the TOT's lexical node in order to resolve the TOT. In contrast, a higher-frequency first syllable connects to many lexical nodes which then can compete with the TOT word for receiving enough activation to be retrieved.

Phonology and the Mandarin Syllable

There are relatively few studies on Mandarin TOTs, and these have focused primarily on non-linguistic factors such as semantic distraction, bilingualism, or aging that affect TOT

incidence—the likelihood of experiencing a TOT—rather than TOT resolution (e.g., Chen et al., 2013; Peng & Mao, 2018). Only one study to date has used a phonological priming methodology (Ouyang et al., 2020). Prior to naming pictures of celebrities, Ouyang et al. (2020, Experiment 2) presented phonological primes that contained the picture’s first name or the first syllable of the first name. They also manipulated semantic relatedness of primes as sharing or not sharing the celebrity’s occupation. Focusing on the results most relevant for the present experiments, younger-aged participants demonstrated phonological priming of TOT incidence when primes shared occupation. Specifically, there were fewer TOTs following first name primes than first syllable primes or unrelated primes. However, when using a proportional measure of TOTs as a function of all correct retrievals (e.g., Gollan & Brown, 2006), first syllable primes also decreased TOTs relative to unrelated primes. Consistent with the Transmission Deficit model, these results suggest a role for strengthening phonological connections in Mandarin, at least in terms of reducing TOT occurrences. However, the less consistent priming effect from first syllable primes in Mandarin may be influenced by cross-linguistic differences between the Mandarin and English syllable.

One such difference is the complexity of the syllable: the makeup of Mandarin syllables is relatively simple, allowing up to one phoneme on either side of a vowel, whereas English syllables can include complex consonant clusters on either side of a vowel. Of possible relevance to TOTs is that Mandarin has considerably fewer syllables than English. There are only about 400 Mandarin syllables, with 1200 syllables if tone is taken into account (Chen et al., 2002), whereas English uses over 12,000 distinct syllables (Farrell & Abrams, 2011). Furthermore, unlike most English syllables, Mandarin syllables are often homophones, i.e., one syllable corresponds to multiple morphemes, where each morpheme typically maps onto a distinct

character, and vice versa (Chen et al., 2002). The average Mandarin syllable corresponds to four distinct morphemes, and some syllables can represent up to 40 morphemes (Zhou & Marslen-Wilson, 1995). For example, the syllable *dian4* can refer to 电 /dian4/ (“electricity”), 店 /dian4/ (“store”), 殿 /dian4/ (“palace hall”), or 淀 /dian4/ (“sediment”), as well as many other characters that share this syllable. A consequence of these differences is that Mandarin syllables in general have a relatively high frequency compared to English syllables. Given that lower-frequency first syllables increased TOT resolution more than higher-frequency first syllables in English, Mandarin first syllables may be less likely to prime TOT resolution because they are generally higher in frequency.

Another structural difference between English and Mandarin lies in the relationship between phonology and orthography. In alphabetic languages such as English, phonology and orthography are intertwined; the way a word is written (orthography) usually overlaps with how it sounds (phonology), e.g., the letter ‘b’ corresponds to the phoneme /b/. While there are some exceptions, such as sounds like /k/ which can be spelled with the letter ‘k’ or ‘c’, letters in English orthography usually represent a particular sound, and this spelling-sound correspondence is even stronger in languages like Spanish or Italian. As opposed to these alphabetic languages, Mandarin is a morphosyllabic language consisting of one-syllable characters. Characters are combined, usually in pairs or triplets, to form new morphemes. A variety of Mandarin reading, character, and corpora studies have indicated that one can predict the pronunciation of a character based on its written form only about 40% of the time without tone and less than 30% of the time if tonal accuracy is considered (Yeung et al., 2011). Consequently, because of the distinction between the syllable and the character, the syllable is a purely phonological unit separate from how it is written. Therefore, TOT resolution in Mandarin is capable of being

primed independently with phonology, without shared overlap with orthography. In contrast, studies in English, which have used visually presented primes, simultaneously primed both phonology and orthography of the TOT's first syllable, so the contribution of shared orthography to the increase in TOT resolution following priming is unknown.

Radicals and the Mandarin Character

Every Mandarin character consists of basic orthographic units called *radicals*, e.g., the character “红” (*red*) is composed of two radicals, the radical “纟” and the radical “工”. Many radicals do not contain strongly associated phonological and semantic meanings, and therefore, they do not definitively indicate the meaning or the sound of a character. Previous studies have used such radicals as primes in speech production tasks to assess orthographic effects independent from phonology and semantics. For example, Zhang et al. (2009) showed that distractors sharing a target picture's radical and general structure of the character sped picture naming, regardless of distractor onset occurring before, during, or after the picture was shown. In general, Mandarin studies using a picture-word interference task have shown that radicals alone can facilitate speech production independently of phonology (Qu & Damian, 2019; Zhang et al., 2009; Zhao et al., 2012).

Although priming with radicals has been shown to facilitate word retrieval in tasks with successful lexical retrieval like picture naming, it is unknown whether radical primes can provide sufficient activation to increase TOT resolution. To our knowledge, there are no prior studies of TOT resolution with orthographic primes, likely because of the strong sound-spelling correspondence in English. If the causes of TOTs are solely phonological, then priming orthography without phonology may be insufficient for resolving TOTs. Furthermore, it is also unknown whether the frequency of an orthographic component plays a role in TOT resolution, as

has been shown with a phonological component like first syllable frequency. Because phonological and orthographic representations are connected to each other within our lexical networks, presentation of a first radical prime will transmit activation to all words containing that radical, and those words' phonological nodes will then receive some activation. Whether the target or a different word gets the most activation for retrieval and affects TOT resolution, as a function of the radical's frequency, remains to be determined.

In sum, Mandarin's distinctive linguistic properties provide an opportunity to examine whether phonology and orthography independently contribute to TOT resolution. To explore, these issues, the present research conducted two experiments assessing the retrieval of cheng-yu targets by native Mandarin speakers. Cheng-yus are four-syllable idioms that have cultural significance in Chinese culture (Wu, 1995). Although idioms have been used in English TOT studies (Nordmann et al., 2013), cheng-yus have never previously been used in TOT experiments. We chose them as targets in our experiment for several reasons. First, many cheng-yus occur with low frequency and longer lengths than typical two- or three-character Chinese words, conditions that have been shown to induce TOT states in English (e.g., Harley & Bown, 1998). Second, cheng-yus have very specific definitions, which makes them excellent targets for general knowledge questions to induce TOTs. Third, cheng-yus provide a way to standardise target length to exactly four characters/syllables, which in turn allows for consistent overlap in the proportion of each target that was primed.

Experiment 1 focused on phonological influences by investigating whether first syllable priming of TOT resolution occurs in Mandarin and whether a prime's first syllable frequency contributes to a priming effect if one exists. The availability of the first syllable during unresolved TOTs was also measured. Experiment 2 explored orthographic influences with

primes containing a radical of the TOT's first character and examined whether the frequency of the prime's radical affects the rate of TOT resolution.

Experiment 1

Experiment 1 was designed to test for a phonological priming effect, independent of orthography, on TOT resolution in Mandarin speakers. Two types of phonological primes were included: words that shared the TOT word's first syllable or its first phoneme. In English, the first syllable but not the first phoneme increased TOT resolution (Abrams et al., 2003), so we included both types of primes for comparison in Mandarin. According to the Transmission Deficit model, TOTs occur when the connections between the lexical node and the phonological nodes are weakened, so strengthening the first syllable phonological connections in Mandarin should similarly result in increased TOT resolution. For example, resolution of a TOT for a target such as “仗义疏财” /zhang4yi4shu1cai2/ could potentially be primed by a word sharing its first syllable /zhang4/, e.g., “帐子”/zhang4zi0/. However, it is possible that the priming effect may be weaker than that observed in English and other alphabetic languages because of Mandarin's relatively high syllable frequency, a factor shown to reduce TOT resolution in English speakers (Farrell & Abrams, 2011).

Method

Participants

Participants included 54 native Mandarin speakers (41 females), aged 18 to 25 ($M = 20.26$ years, $SD = 2.24$) who were university students residing in the general Shanghai area and were subsequently tested at East China Normal University. Sample size was chosen to be comparable with previous studies of English TOT resolution (e.g., Abrams & Rodriguez, 2005; Abrams et al., 2003) and Mandarin TOT incidence (e.g., Ouyang et al., 2020), which used

between 40 and 60 participants. The size of phonological priming effects in TOT resolution varies across studies based on number of phonological primes used, the number of times a prime is presented, etc., so we used $\eta_p^2 = .10$ to estimate a comparable effect. Based on a repeated measures design, G*Power (Faul et al., 2007) suggested a minimum sample size of 46 to ensure power of .80 to detect an effect size $f(U)$ of .33. Data from three participants were excluded due to technical problems with the computer programme used to conduct the experiment and were not included in any further analysis. Participants received 60 RMB \approx \$9 for their participation.

Because the Chinese education system requires students to learn English, participants filled out a subset of the Mandarin version of the LEAP-Q (Language Experience and Proficiency Questionnaire) developed by Marian et al. (2007), which collects information about bilingual speakers' language proficiency and experience. Participants were either bilingual (67%) or multilingual (33%) and reported that their native language, and most dominant language, was Mandarin. The majority of participants (98%) reported that they were exposed to Mandarin at least 50% of the time in everyday life. With respect to self-rated English proficiency on a 10-point scale with 10 being most proficient, participants rated themselves as reasonably proficient in speaking English ($M = 6.25$, $SD = 1.91$), comprehending English ($M = 6.51$, $SD = 2.02$), and reading English ($M = 7.20$, $SD = 1.80$).

Materials

Targets, Primes, Controls, and Filler Words. We selected 100 cheng-yu (成语) targets and created a question for each that described the cheng-yu's meaning in an attempt to induce TOTs. Each target was paired with a two-character word in three different conditions (see Table 1 for examples): (1) a *first phoneme prime* which contained the target's first phoneme and had the same tone as the target's first syllable, (2) a *first syllable prime* containing the target's first

syllable with the same tone,¹ and (3) an *unrelated control word* with no morphological or phonological overlap with the target. Critically, both prime conditions had no orthographic overlap with the target, as the first character was different from that of the target. Four filler words were created for each target consisting of two- or three-character words with no semantic, phonological, or morphological overlap with the cheng-yu. A complete list of the stimuli described above are displayed in the Supplemental Materials.

(Table 1 about here)

Questionnaires. Two pre- and one post-experiment questionnaires were given to all participants. The first pre-experiment questionnaire asked about participants' demographic information, health, and previous experience with various languages. The second pre-experiment questionnaire was a subset of the Mandarin version of the LEAP-Q, which assessed participants' language backgrounds. The post-experiment questionnaire checked whether participants guessed the intention of the experiment or the relation between the target words and the prime words, as well as their use of that relation to facilitate retrieval of target words.

Design and Procedure

The experiment—including participant instructions, questionnaires, the computer programme, and any verbal interactions with the participant—was conducted entirely in Mandarin using an executable programme written in Visual Basic 5.0 on a PC. The experiment was based on the experimental paradigm used by Abrams et al. (2003) and included one within-participants factor, priming condition, with three levels (first phoneme primes, first syllable primes, and unrelated control words). Before the experiment, participants filled out questionnaires collecting demographic information as well as the modified LEAP-Q. They then were given a printed sheet which had an explanation of the TOT phenomenon as well as

instructions on the tasks that they would complete during the experiment. The TOT phenomenon was described as follows (translated from Mandarin): “When a tip-of-the-tongue state happens, you know the cheng-yu’s definition, as well as when and how to use the cheng-yu in a sentence. You might know the first character/word or how it sounds. The tip-of-the-tongue state is different from feeling like you *should* know the word. In a tip-of-the tongue state, you might feel the cheng-yu is on the tip of your tongue, and you might feel frustrated that you can’t think of the cheng-yu.”

After confirming that participants understood what a TOT was, participants began the experimental procedure, which is outlined in Figure 1. Participants saw target questions one-by-one in the centre of a computer screen. After reading each target question, participants responded by typing “Z” if they knew the target word, “B” if they did not know the target word, or “S” if they were experiencing a TOT state. Afterwards, participants saw five words one at a time and rated each word for how frequently they encountered the word on a 10-point scale, with 1 being that they never encountered it to 10 being that they encountered it every day. The second word in the list was either a prime or a control, and the other words were fillers. If the participant selected “Don’t Know” or “TOT,” the computer programme randomly selected which of the three priming conditions were shown, with the constraint that all three conditions were selected before repeating one of them (see also White & Abrams, 2002, for a similar procedure). After rating the words, the previous target question was re-presented, and participants were asked to answer it again with “Know”, “Don’t Know”, or “TOT.” If participants entered “Know”, they were asked to type in the correct answer. If they entered “Don’t Know” or “TOT”, they were asked to type in any information they could remember about the target word, including the first word/character, another cheng-yu, or words that came to mind. If the participant initially selected “Know” after

reading the question, they were prompted to type in the answer and then saw a five-word list which always contained the control word. After rating all of the words, a new question was presented. There were no time limits imposed within a trial.

After all 100 questions were presented, participants completed a multiple-choice recognition test, where any unresolved question (i.e., whose target remained unretrieved on the second presentation of the question) was presented with four possible answers: (1) the correct target, (2) a semantically and phonologically related cheng-yu, (3) a semantically related but phonologically unrelated cheng-yu, and (4) a cheng-yu with no semantic or phonological overlap. Each of the choices was presented with the letter A, B, C, or D, which participants used to select their answer. The target position was counterbalanced so that it appeared equally often in the four possible answer choices across all 100 questions. The entire experimental session lasted approximately an hour and a half.

(Figure 1 about here)

Results and Discussion

Participants' responses to the post-experimental questionnaire were reviewed to see whether participants were aware of and able to use the priming manipulation (the phonological relationship between primes and targets) to intentionally retrieve the target cheng-yu. One participant correctly identified the phonological relationship between the primes and target questions but was unable to use this relation in any strategic way and was therefore included in analyses. Participants who did not have at least two TOTs in each of the three priming conditions ($N = 6$) were excluded from analysis to ensure that mean resolution in each priming condition was based on multiple TOT occurrences. One item whose first syllable prime inadvertently did

not match its cheng-yu target was excluded from analysis. All analyses were conducted using participants as the unit of analysis.²

Responses to Target Questions

The initial responses to the target questions were categorised into five possible responses: correct “Know”, incorrect “Know”, correct “TOT”, incorrect “TOT”, and “Don’t Know”. Correct “Know” responses were responses where participants indicated knowing the answer and then retrieved the target, while incorrect “Know” responses occurred if participants indicated knowing the answer but retrieved an answer other than the target. “TOT” responses were categorised as correct when participants provided the correct answer to the target question on its second presentation or chose the correct response on the multiple choice recognition test; otherwise, “TOT” responses were designated as incorrect. Lastly, “Don’t Know” responses occurred when participants selected “Don’t Know” as a response to the target question. The participant means and standard deviations of the number of correct and incorrect responses to the general knowledge questions are shown in Table 2.

(Table 2 about here)

Phonological Priming

TOT resolution, i.e., the percentage of resolved TOTs (retrieving the target) among all correct TOTs experienced, was calculated for each priming condition. The means and standard errors of the percentage of TOT resolution are displayed in Figure 2, and the number of resolved and unresolved TOTs are shown in Table 3. Consistent with other TOT studies (Abrams & Rodriguez, 2005; Abrams et al., 2003; Ouyang et al., 2020), the mean proportion of TOT resolution was analysed using a repeated measures ANOVA with Priming Condition (first phoneme prime, first syllable prime, unrelated control) as a factor. The ANOVA showed no

significant main effect, $F(2, 88) = 1.23$, $MSE = .04$, $p = .297$, $\eta_p^2 = .03$. However, because our hypothesis was specific to first syllable priming, we also conducted a planned comparison t-test between the first syllable prime and unrelated control conditions which revealed a marginally significant effect, $t(44) = 1.74$, $SE_{\text{Mean}} = .03$, $p = .089$, $\eta_p^2 = .07$. In contrast, no difference emerged between the first phoneme prime and unrelated control conditions, $t(44) = .56$, $SE_{\text{Mean}} = .03$, $p = .58$, $\eta_p^2 = .01$.

(Figure 2 about here)

(Table 3 about here)

Partial Recall during Unresolved TOT States

To further our understanding of the marginally significant first syllable priming effect, we descriptively categorised partial information available during TOT states, i.e., any information about the target word that could be recalled. Partial information consisted of cheng-yus related to the target, incorrect or made-up cheng-yus, words with two or three characters, or single characters. Recall only included characters, never individual phonemes or radicals. We then focused on recall of the target's first character, which would be evidence of having access to the target's first syllable. A paired-samples t-test, $t(44) = -3.16$, $SE_{\text{Mean}} = .02$, $p = .003$, $\eta_p^2 = .18$, showed that during TOTs participants retrieved the target's first character ($M = 9.5\%$, $SD = 13.7\%$) less often than other characters within the target ($M = 16.6\%$, $SD = 13.2\%$). Furthermore, priming had no effect on retrieving the first character, $F(2, 86) = .13$, $MSE = .02$, $p = .88$, $\eta_p^2 = .003$, as priming the first syllable ($M = 8.6\%$, $SD = 19.9$) or first phoneme ($M = 9.3\%$, $SD = 15.5$) resulted in similar proportions of recall relative to the control word ($M = 7.7\%$, $SD = 12.1$). Lastly, when participants did recall the first character of a target, a one sample chi-square test showed that they recalled it in various positions within their answers ($X^2(5, N = 54) = 24.67$, $p <$

.001). Contrary to expected frequencies of 16.6%, participants more often recalled the character by itself (22%) or within a shorter, two- or three-character word (26%). When recalling the character within a cheng-yu different from the target, participants were most likely to recall the character in the first position (33%), followed by the fourth (final) position (11%), and least likely to recall it in the second position (4%) or third position (4%).

First Syllable Frequency

We conducted analyses on whether the frequency of the first syllable shared by the target and prime words influenced TOT resolution. Atonal syllable frequencies, i.e., syllables independent of tone (e.g., /tai/), and tonal syllable frequency (syllables marked with tone, e.g., /tai1/, /tai2/, /tai3/, or /tai4/ for the syllable /tai/) were determined based on a corpus containing the 3,500 most frequent Chinese syllables (Da, 2004), with syllable frequency representing the number of times a syllable occurred in any position within a Mandarin word in the corpus. First syllables were categorised using a median split of the number of times the syllable appeared in the corpus ($Mdn_{\text{Atonal}} = 648,320$; $Mdn_{\text{Tonal}} = 155,921$). Syllables with occurrences above the median were designated as higher frequency ($M_{\text{Atonal}} = 1,424,399$; $M_{\text{Tonal}} = 431,589$) while syllables at or below the median were considered lower frequency ($M_{\text{Atonal}} = 309,700$; $M_{\text{Tonal}} = 60,401$). A paired-samples t-test compared higher and lower first syllable frequency groups on mean proportion of TOT resolution following first syllable primes, excluding five participants who did not have TOTs in both syllable frequency categories (for atonal, exclusions were three participants without TOTs for higher syllable frequency targets and two participants for lower syllable frequency targets; for tonal, exclusions were two participants without TOTs for higher syllable frequency targets and three participants for lower syllable frequency targets). For atonal first syllable frequency, there was no significant effect, $t(39) = -1.58$, $SE_{\text{Mean}} = .06$, $p = .121$, η_p^2

= .06, as TOT resolution was equivalent for higher frequency atonal first syllables ($M = 14.2\%$, $SD = 24.7\%$) and lower frequency atonal first syllables ($M = 24.1\%$, $SD = 33.0\%$). A paired-samples t-test comparing tonal first syllable frequency groups similarly found no difference, $t(39) = -1.53$, $SE_{\text{Mean}} = .06$, $p = .135$, $\eta_p^2 = .06$, between higher frequency first syllables ($M = 12.5\%$, $SD = 22.6\%$) and lower frequency first syllables ($M = 21.4\%$, $SD = 30.6\%$).

Discussion

Experiment 1 examined whether the resolution of TOT states in Mandarin is modulated by phonological priming, specifically with primes that contained either the first syllable or first phoneme of the target. There was marginally higher TOT resolution following first syllable primes relative to unrelated words, an effect that did not occur for first phoneme primes. These results suggest that encountering the first syllable during Mandarin TOT states somewhat strengthens the weakened phonological connections causing TOTs. However, first syllable priming of TOT resolution in Mandarin seems to be weaker than the first syllable priming effects observed in TOT experiments with comparable sample sizes in English (e.g., Abrams & Rodriguez, 2005; Abrams et al., 2003) and other alphabetic languages (Hofferberth-Sauer & Abrams, 2014; Pureza et al., 2013). Another difference we observed is that first syllable frequency did not significantly affect Mandarin TOT resolution, contrary to findings in English (Farrell & Abrams, 2011).

One difference between prior studies and ours is that our phonological primes did not overlap orthographically with the target, i.e., primes had the same first syllable but a different first character from the target. This dissociation is not easily achieved in TOT studies in English, where previous studies in English functionally primed both phonology and orthography because English's alphabetic writing system uses letters to represent phonemes. Thus, phonological

priming without simultaneous orthographic overlap may be less effective in resolving TOTs, suggesting that orthography may also contribute to resolving TOT states. In Experiment 2, we explored whether orthography independent of phonology plays any role in TOT resolution.

Experiment 2

In Experiment 2, the goal was to test whether orthographic components without phonological overlap, specifically the first radical in the target cheng-yu's first character, can increase TOT resolution. Radical primes have previously been shown to facilitate speech production in other tasks, such as picture-word interference (Zhang et al., 2009), but it is unknown if these primes can influence speech production in a task where phonology is compromised like TOT resolution. Priming orthographic components like radicals may *indirectly* transmit activation to phonological nodes that could influence TOT resolution by virtue of activating other words with that same radical. For example, during a TOT for “借花献佛”, encountering a prime word like “仍然” would transmit activation to the shared radical “亻”, which in turn sends activation to characters with that radical. One of these characters is the target's first character, “借”, which sends activation to its corresponding syllable “jie3” and could potentially help resolve the TOT. However, this indirect nature of activating the target's phonological nodes may be insufficient to achieve TOT resolution. We also explored whether the frequency of the first radical plays a role in resolution of Mandarin TOTs and whether its impact is similar to or different from phonological frequency measures like first syllable frequency.

Method

Participants

Sixty undergraduate students from Beijing Normal University and Chinese Academia of Science Institute of Psychology in Beijing were recruited to participate. All were native

Mandarin speakers (40 female) and ranged in age from 18 to 28 ($M = 21.2$ years, $SD = 2.5$). Data from five participants were excluded from further analysis due to computer programme problems. The LEAP-Q results of the remaining participants showed that they self-identified as either bilingual (84%) or trilingual (16%) but that Mandarin was their dominant language, reporting exposure to Mandarin in their everyday life at least 60% of the time and more frequently than any other languages. Self-rated English proficiency in speaking ($M = 4.26$, $SD = 1.47$), comprehending ($M = 4.91$, $SD = 1.74$), and reading English ($M = 5.88$, $SD = 1.67$) was slightly lower than that reported in Experiment 1. Participants were compensated with 100 RMB \approx \$15 for their participation upon the completion of the experiment.

Materials

The same 100 cheng-yu targets, unrelated control words, filler words, and target questions from Experiment 1 were used in this experiment. Primes were modified such that each target was assigned a two-character prime word that shared the radical with the first character of the target word (see Table 1 for examples). First radical primes were chosen so that their shared radical with the target had no phonological associations. Participants completed the same pre- and post-experiment questionnaires and multiple-choice recognition test as in Experiment 1.

Design and Procedure

The experiment included one within-participants factor, priming condition, with two levels: first radical primes and unrelated control words. The procedure of Experiment 2 was the same as that in Experiment 1, except that the second word in the list of five words—presented after participants responded to each target question—was either a radical prime or a control. The computer programme randomly selected between the two conditions, with the constraint that both conditions were selected before repeating one of them.

Results and Discussion

Responses on the post-experimental questionnaire demonstrated that no participants detected a relationship between the primes and targets, specifically the orthographic overlap. Using the same exclusion criteria as Experiment 1, participants who did not have at least two TOTs in each of the two priming conditions ($N = 3$) were excluded from subsequent analyses. One target whose radical prime inadvertently did not match its cheng-yu target was excluded from analysis. All analyses were conducted using participants as the unit of analysis.

Responses to Target Questions

Participants' initial responses were categorised and revealed a distribution similar to Experiment 1; see Table 2.

Orthographic Priming

Mean proportion of TOT resolution for correct TOT responses was calculated for TOTs in the two priming conditions (see also Table 3 for number of resolved and unresolved TOTs). A paired-samples t-test, $t(51) = -.25$, $SE_{\text{Mean}} = .03$, $p = .807$, $\eta_p^2 = .00$, showed no difference between first radical primes ($M = 16.1\%$, $SD = 15.0\%$) and unrelated control words ($M = 16.8\%$, $SD = 18.8\%$). The priming effect was not significant, so it did not warrant further exploration via the partial recall of information, as was done in Experiment 1.

First Radical Frequency

The frequency of the radical shared by the target and prime's first character was taken from Xun et al. (2016), which was based on the *People's Daily Corpus* (人民日报语料库) and computed as the number of appearances of a specific radical divided by the total number of radicals. A median split ($Mdn = 0.008629$) categorised the radicals with frequencies above the median as higher frequency ($M = .014$) and ones below the median as lower frequency ($M =$

.006). A paired-samples t-test comparing the two radical frequency groups on mean proportion of TOT resolution following first radical primes (excluding four participants who did not have TOTs for higher radical frequency targets) trended toward significance, $t(47) = 1.65$, $SE_{\text{Mean}} = 0.04$, $p = .105$, $\eta_p^2 = .06$, such that TOTs containing higher frequency first radicals were more likely to be resolved ($M = 20.1\%$, $SD = 27.4\%$) than lower frequency first radicals ($M = 12.8\%$, $SD = 15.3\%$). This effect was specific to TOT resolution following radical primes, as a t-test comparing the two radical frequency groups' TOT resolution following unrelated control words was not significant, $t(50) = .99$, $SE_{\text{Mean}} = 0.04$, $p = .328$, $\eta_p^2 = .02$.

Discussion

Experiment 2 investigated whether first radical priming independent of phonological overlap affects TOT resolution in Mandarin. Unlike the marginal first syllable priming effect in Experiment 1, we did not find an effect from orthographic primes whose first character shared the target's first radical relative to an unrelated control word. This result suggests that priming the first radical of the target was likely insufficient for transmitting the activation to the target's phonological nodes necessary to enable target retrieval, which is consistent with the explanation of TOTs as arising from weakened phonological connections (Burke et al., 1991; MacKay & Burke, 1990). However, participants were marginally more likely to resolve TOTs when presented with primes having a higher frequency first radical than a lower frequency first radical, suggesting that the orthographic system played some role in TOT resolution which is described in more detail below.

General Discussion

The results of the two experiments reported here show that cheng-yus can be used to induce TOTs in Mandarin and provide new insight into the processes underlying TOT resolution

for Mandarin speakers. Specifically, we identified two factors that had a marginal influence on TOT resolution in Mandarin: first syllable priming independent of orthographic overlap and first radical frequency. In contrast, analyses of first phoneme priming, first syllable frequency, and first radical priming did not reveal any effects. The trend toward first syllable priming of TOT resolution supports the phonological locus of TOTs and extends Ouyang et al. (2020)'s finding of first syllable priming on TOT incidence to include TOT resolution. Our marginal effect seems similar to the inconsistency of their first syllable priming effect, which occurred only when a proportional measure of TOT incidence was used. In comparison, first syllable priming of TOT resolution in English and Indo-European languages is larger and more consistently observed (e.g., Abrams et al., 2003; Hofferberth-Sauer & Abrams, 2014). Unfortunately, directly comparing TOT resolution across experiments in different languages is difficult because of stimuli differences, which in turn could affect the rate of TOT resolution through differences among targets' psycholinguistic properties. Nonetheless, existing theoretical explanations of TOTs in other languages can help to interpret our results for Mandarin TOT resolution. We adapted the Transmission Deficit model of TOTs (e.g., Burke et al., 1991; MacKay & Burke, 1990) for Mandarin, shown in Figure 3, which shows the hierarchically organised network of nodes for the target word “借花献佛”, displaying both its phonological and orthographic systems.

(Figure 3 about here)

The red arrows in Figure 3 demonstrate how phonological priming can be accomplished. The first syllable prime, “介意”, sends activation top-down to its connected syllables starting with its initial one, /jie/. This node will send activation bottom-up to connected lexical nodes, one of which is the target “借花献佛”, and TOT resolution will occur if enough activation is

received. This priming effect is weaker compared to first syllable priming effects found in TOT studies in English and other alphabetic languages. For example, significant priming of TOT resolution in English has been demonstrated in studies with fewer correct TOTs (8-9%) than that observed in the present studies, which was 18-19% (e.g., Abrams & Rodriguez, 2005; Abrams et al., 2007). We propose two unique characteristics of the Mandarin syllable that may reduce the effectiveness of first syllable priming.

One such characteristic is the Mandarin syllable's relatively high frequency; because Mandarin has only about 400 syllables (Chen et al., 2002), each syllable occurs in many words. Consequently, priming the first syllable node will send activation to a large set of lexical nodes representing words that begin with that syllable, not just the target. A syllable in Mandarin connects to many lexical nodes, not only words beginning with the target's character but also words beginning with homophones of the character (see Figure 3). For example, the syllable /jie/ connects to words beginning with “借”, “介”, or “戒”. This diffuse spread of activation may decrease the efficacy of strengthening the target's phonological connections sufficiently to ensure TOT resolution, as some of these connected lexical nodes, especially those that are higher frequency words, may compete with the target for retrieval. A similar idea has been used to explain why English TOT resolution following primes with high frequency first syllables is less effective than words with low-frequency first syllables (Farrell & Abrams, 2011), an effect we did not observe in Mandarin. In Mandarin, even a lower-frequency first syllable has a relatively high frequency compared to other languages where higher and lower first syllable frequency groups are more distinct and can differentially affect TOT resolution (Farrell & Abrams, 2011; Pureza et al., 2013). It is worth noting that the means in our first syllable frequency analyses

trended in the same direction as has been shown with English, so perhaps a finer categorisation of first syllable frequency rather than a median split could reveal a significant effect in Mandarin.

Another factor that may have reduced the effectiveness of first syllable priming of TOT resolution is that Mandarin is a morphosyllabic language where each character or syllable is individually meaningful, which could make the first syllable less critical for resolving TOTs. This idea is supported by participants' recall of partial phonological information during unresolved TOTs, where other syllables besides the first syllable were more likely to be recalled. In Mandarin, a word or cheng-yu consisting of multiple characters may have its most salient semantic constituent in the middle or end of the word, not in the first syllable. Therefore, other syllables besides the first syllable may sometimes be easier to recall or prime. Furthermore, even when the first syllable was recalled, it frequently appeared in a position different from the initial position. This finding indicates that Mandarin may have more flexible syllable encoding during the language production process, in line with speech error studies showing that entire Mandarin syllables can switch places in normal speech production (Chen, 2000). Current TOT studies in English assume that sequential left-to-right activation must occur for a word to be fully retrieved, hence why the first syllable is so critical for TOT resolution (MacKay, 1987). Further studies might examine whether Mandarin requires this linear activation to the same degree that English does. In any case, it is important to acknowledge that these possible influences of Mandarin syllable characteristics in reducing TOT resolution are speculative, and further studies in Mandarin are needed to assess whether the processes underlying the resolution of cheng-yu TOTs are different from those of common and proper nouns. Furthermore, marginally significant priming as was observed in our experiment suggests a trend that is worth exploring in further

research, and future studies of Mandarin TOT resolution could use stimuli whose phonological and lexical properties are similar to those used in TOT studies of other languages.

Because our phonological primes did not share the target's orthography, a smaller phonological priming effect in Mandarin is also consistent with the idea that the orthography of visually presented primes might play a role in TOT resolution. Indeed, the orthographic network in the Mandarin model may indirectly affect TOT resolution through character-to-syllable connections, supported by our findings of a marginal first radical frequency effect. When primed with first radical primes, TOT targets were more likely to be resolved when the first radical shared between the primes and targets was higher frequency than lower frequency. The blue arrows in Figure 3 demonstrate that when a radical is primed during a TOT for the target “借花献佛”, the prime's lexical node “仍然” sends activation top-down to its associated character node “仍”, which then transmits activation down to its radical nodes, the first of which is “亻”.³ Radical nodes then spread activation back up to all of the character nodes containing that radical (e.g., “借”, “作”, “仍”, and “但”), and each of these character nodes sends activation laterally to syllable nodes in the phonological system. The target could potentially get activated by the character-to-syllable connection, as the radical will send activation to the character node “借” and then to the syllable /jie/. Because activation spreads across many intervening connections, the likelihood of the target's syllable node receiving sufficient activation to then facilitate TOT resolution is relatively low overall, suggesting that first radicals may not elicit a priming effect, as was the case in our experiment. However, higher frequency radicals are accessed and used more often throughout a person's lifetime, and consequently their character-to-syllable connections are stronger. Connections like these transmit activation more strongly from the

character node to the target's syllable node (see the thickest blue arrow in Figure 3), which increases the likelihood of TOT resolution relative to a lower frequency first radical.

Interestingly, the radical frequency effect in Mandarin is in the opposite direction as the first syllable frequency effect in English, in which priming higher frequency syllables is less effective for TOT resolution (Farrell & Abrams, 2011). Unlike the priming of syllables, priming radicals does not elicit potential competition between lexical nodes because a single radical node is connected to a phonologically heterogeneous set of character nodes, which do not necessarily share any phonology with the TOT targets. Although character nodes involve the same radical, the syllables with which they are associated can be very different in phonology (e.g., the characters “借” and “作” share the radical “亻” but are connected to different syllables, /jie/ and /zuo/, respectively; see Figure 3). It is worth highlighting that higher frequency first radicals increased TOT resolution relative only to lower frequency first radicals, not unrelated words. The failure to observe a first radical priming effect is consistent with the idea that orthographic primes cannot directly activate the target's phonological nodes in the Mandarin model the way that phonological primes can (see Figure 3). Given past studies showing the effectiveness of orthographic primes in cases of successful speech production (Qu & Damian, 2019; Zhang et al., 2009; Zhao et al., 2012), it is possible that orthographic primes facilitate language production when the target phonological connections are intact but fail to completely activate weakened connections in the case of TOTs. Furthermore, while the present study specifically used radicals without phonological overlap, there is a class of radicals in Mandarin called phonological radicals. Characters containing these radicals can be associated with the same or similar syllables, and future research should investigate whether priming TOT resolution with these types of radicals differentially affects TOT resolution.

Conclusions

The present study examined how phonological and orthographic systems independently influence TOT resolution in Mandarin speakers and revealed both similarities and differences relative to previous research with alphabetic languages. The main similarity can be seen in the importance of accessing the TOT word's initial syllable, which seems to be a critical component for its resolution, although to a lesser degree in Mandarin. More broadly, this suggests that the first units of lexical items play an important role in speech production for left-to-right languages regardless of different linguistic and writing systems. In contrast, our findings with Mandarin differ in that the frequency of a prime's first radical, an orthographic component, slightly modulates TOT resolution. Our proposed Transmission Deficit model for Mandarin TOT resolution posits that the phonological and orthographic systems are linked mainly through syllable-character connections that can facilitate TOT resolution when the frequency of usage of those connections is high. Whether this orthographic effect is unique to a character-based language such as Mandarin remains a possible direction for future studies.

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Disclosure of Interest Statement

The authors report no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available in the Open Science Framework at

<https://osf.io/bqv9g/>. None of the experiments were preregistered.

References

- Abrams, L., & Rodriguez, E. L. (2005). Syntactic class influences phonological priming of tip-of-the-tongue resolution. *Psychonomic Bulletin & Review*, *12*(6), 1018–1023.
<https://doi.org/10.3758/BF03206437>
- Abrams, L., Trunk, D. L., & Merrill, L. A. (2007). Why a superman cannot help a tsunami: Activation of grammatical class influences resolution of young and older adults' tip-of-the-tongue states. *Psychology and Aging*, *22*(4), 835–845. <https://doi.org/10.1037/0882-7974.22.4.835>
- Abrams, L., White, K. K., & Eitel, S. L. (2003). Isolating phonological components that increase tip-of-the-tongue resolution. *Memory & Cognition*, *31*(8), 1153–1162.
<https://doi.org/10.3758/bf03195798>
- Borodkin, K., Maliniak, O., & Faust, M. (2017). Exploring the nature of phonological weakness in low-proficiency second language learners. *Learning and Individual Differences*, *57*, 133-140. <https://doi.org/10.1016/j.lindif.2017.04.005>
- Brown, R., & McNeill, D. (1966). The “tip of the tongue” phenomenon. *Journal of Verbal Learning and Verbal Behavior*, *5*(4), 325-337. [https://doi.org/10.1016/S0022-5371\(66\)80040-3](https://doi.org/10.1016/S0022-5371(66)80040-3)
- 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. [https://doi.org/10.1016/0749-596X\(91\)90026-G](https://doi.org/10.1016/0749-596X(91)90026-G)
- Chen, J., Su, L., Zhang J., & Xing, S. (2013). The product mechanism of diglossias TOT: Evidence from Mandarin-Cantonese diglossias. *Journal of Psychological Science*, *36*(1), 27-32. <https://doi.org/10.16719/j.cnki.1671-6981.2013.01.019>

Chen, J.-Y. (2000). Syllable errors from naturalistic slips of the tongue in Mandarin Chinese.

Psychologia: An International Journal of Psychology in the Orient, 43(1), 15–26.

Chen, J.-Y., Chen, T.-M., & Dell, G. S. (2002). Word-form encoding in Mandarin Chinese as

assessed by the implicit priming task. *Journal of Memory and Language*, 46(4), 751–781.

<https://doi.org/10.1006/jmla.2001.2825>

Da, J. (2004). A corpus-based study of character and bigram frequencies in Chinese e-texts and

its implications for Chinese language instruction. In Z. Pu, T. Xie & Juan Xu (Eds.), *The*

studies on the theory and methodology of the digitised Chinese teaching to foreigners:

Proceedings of the 4th International Conference on New Technologies in Teaching and

Learning Chinese (pp. 501-511). The Tsinghua University Press.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production.

Psychological Review, 93(3), 283-321. <http://dx.doi.org/10.1037/0033-295X.93.3.283>

Ecke, P. (1996). *Cross-language studies of lexical retrieval: Tip-of-the-tongue states in first and*

foreign languages (Doctoral Thesis, University of Arizona, Tucson, United States).

Retrieved from <https://repository.arizona.edu/handle/10150/282099>.

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. <https://doi.org/10.1037/a0021328>

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical

power analysis programme for the social, behavioural, and biomedical sciences. *Behavior*

Research Methods, 39(2), 175-191. <https://doi.org/10.3758/bf03193146>

- 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*, 135(3), 462–483. <https://doi.org/10.1037/0096-3445.135.3.462>
- Gollan, T. H., & Silverberg, N. B. (2001). Tip-of-the-tongue states in Hebrew–English bilinguals. *Bilingualism: Language and Cognition*, 4(1), 63–83. <https://doi.org/10.1017/S136672890100013Xh>
- 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. <https://doi.org/10.1111/j.2044-8295.1998.tb02677.x>
- Hofferberth-Sauer, N. J., & Abrams, L. (2014). Resolving tip-of-the-tongue states with syllables cues. In V. Torrens & L. Escobar (Eds.), *The processing of lexicon and morphosyntax* (pp. 43-68). Newcastle: Cambridge Scholars Publishing.
- James, L. E., & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26(6), 1378–1391. <https://doi.org/10.1037/0278-7393.26.6.1378>
- Koriat, A., & Lieblich, I. (1974). What does a person in a “TOT” state know that a person in a “don’t know” state doesn’t know. *Memory & Cognition*, 2(4), 647–655. <https://doi.org/10.3758/BF03198134>
- Levelt, W. J. M. (1989). ACL-MIT Press series in natural-language processing. *Speaking: From intention to articulation*. The MIT Press.
- MacKay, D. (1987). *The organization of perception and action*. Springer-Verlag.

- MacKay, D. G., & Burke, D. M. (1990). Cognition and aging: A theory of new learning and the use of old connections. In *Aging and cognition: Knowledge organization and utilization* (pp. 213–263). North-Holland. [https://doi.org/10.1016/S0166-4115\(08\)60159-4](https://doi.org/10.1016/S0166-4115(08)60159-4)
- Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The language experience and proficiency questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research, 50*(4), 940–967. [https://doi.org/10.1044/1092-4388\(2007/067\)](https://doi.org/10.1044/1092-4388(2007/067))
- Nordmann, E., Cleland, A.A., & Bull, R. (2013). Cat got your tongue? Using the tip-of-the-tongue state to investigate fixed expressions. *Cognitive Science, 37*(8), 1553-1564. <https://doi.org/10.1111/cogs.12060>
- Ouyang, M., Cai, X., & Zhang, Q. (2020). Aging effects on phonological and semantic priming in the tip-of-the-tongue: Evidence from a two-step approach. *Frontiers in Psychology, 11*: 338. <https://doi.org/10.3389/fpsyg.2020.00338>
- Peng, H., & Mao, X. (2018). Will the deficit in inhibition increase the rates of tip-of-the-tongue among the elderly? *Acta Psychologica Sinica, 50*(10), 1142. <https://doi.org/10.3724/SP.J.1041.2018.01142>
- Pureza, R., Soares, A. P., & Comesaña, M. (2013). Syllabic pseudohomophone priming in tip-of-the-tongue states resolution: The role of syllabic position and number of syllables. *Quarterly Journal of Experimental Psychology, 66*(5), 910–926. <https://doi.org/10.1080/17470218.2012.722658>
- Qu, Q., & Damian, M. F. (2019). Orthographic effects in Mandarin spoken language production. *Memory & Cognition, 47*(2), 326–334. <https://doi.org/10.3758/s13421-018-0868-7>

- Shin, H.-I. (2019). Iconicity of Korean Sign Language and “tip of the fingers” experiences. *The Korean Journal of Cognitive and Biological Psychology*, 31(2), 81–88.
<https://doi.org/10.22172/COGBIO.2019.31.2.002>
- Thompson, R., Emmorey, K., & Gollan, T. H. (2005). “Tip of the fingers” experiences by deaf signers: insights into the organization of a sign-based lexicon. *Psychological Science*, 16(11), 856–860. <https://doi.org/10.1111/j.1467-9280.2005.01626.x>
- Vigliocco, G., Antonini, T., & Garrett, M. F. (1997). Grammatical gender is on the tip of Italian tongues. *Psychological Science*, 8(4), 314–317. <https://doi.org/10.1111/j.1467-9280.1997.tb00444.x>
- Vitevitch, M. S., & Sommers, M. S. (2003). The facilitative influence of phonological similarity and neighborhood frequency in speech production in younger and older adults. *Memory & Cognition*, 31(4), 491-504. <https://doi.org/10.3758/bf03196091>
- White, K. K., & Abrams, L. (2002). Does priming specific syllables during tip-of-the-tongue states facilitate word retrieval in older adults? *Psychology and Aging*, 17(2), 226-235.
<https://doi.org/10.1037/0882-7974.17.2.226>
- Wu, C. (1995). On the cultural traits of Chinese idioms. *International Communication Studies*, 5(1), 61-84.
- Xun, E., Rao, G., Xiao, X., & Zang, J. (2016). Development of BCC corpus in the context of big data. *Corpus Linguistics*, 3(1), 93-109.
- Yeung, P., Ho, C. S., Chik, P. P., Lo, L., Luan, H., Chan, D. W. & Chung, K. K. (2011). Reading and spelling Chinese among beginning readers: What skills make a difference?, *Scientific Studies of Reading*, 15(4), 285-313. <https://doi.org/10.1080/10888438.2010.482149>

Zhang, Q., Chen, H.-C., Weekes, B. S., & Yang, Y. (2009). Independent effects of orthographic and phonological facilitation on spoken word production in Mandarin. *Language and Speech*, 52(1), 113–126. <https://doi.org/10.1177/0023830908099885>

Zhao, H., La Heij, W., & Schiller, N. O. (2012). Orthographic and phonological facilitation in speech production: New evidence from picture naming in Chinese. *Acta Psychologica*, 139(2), 272–280. <https://doi.org/10.1016/j.actpsy.2011.12.001>

Zhou, X., & Marslen-Wilson, W. (1995). Morphological structure in the Chinese mental lexicon. *Language and Cognitive Processes*, 10(6), 545–600. <https://doi.org/10.1080/01690969508407114>

Footnotes

1. Three first syllable primes and three first phoneme primes did not have the exact same tone as the target. However, excluding stimuli with tonal differences had no effect on the results.
2. Item analyses were not conducted because the target items were not randomly selected, which can make these analyses inappropriate (Vitevitch & Sommers, 2003) and less powerful. Proportionally more targets are excluded from analysis because TOTs may not occur in every prime condition for a target. Furthermore, participants have TOTs on different subsets of targets, so the by-participant analysis functionally includes item variability.
3. It is important to note that a radical can appear at different spatial locations in constituting different characters. However, since our experimental stimuli focused exclusively on a single kind of spatial configuration of character, i.e., left-right structure, and we were interested in how orthography affects TOTs, we did not represent spatial configuration of radicals in our Transmission Deficit model.

PRIMING OF MANDARIN TOT RESOLUTION

Table 1

Examples of Targets, Prime Words, and Unrelated Control Words

Target	Target pinyin	First phoneme	First phoneme	First syllable	First syllable	First radical	First radical	Unrelated control	Unrelated control
		prime	prime	prime	prime	prime	prime	word	word
			pinyin		pinyin		pinyin	pinyin	pinyin
仗义疏财	zhang4yi4shu1cai2	制定	zhi4 iding4	帐子	zhang4 zi0	仇恨	chou2hen4	联盟	lian2meng2
投笔从戎	tou2bi3cong2rong2	徒弟	tu2 di4	头发	tou2 fa0	抄袭	chao1xi2	海外	hai3wai4
调虎离山	diao4hu3li2shan1	大人	da4 ren2	吊销	diao4 xiao1	记录	ji4lu4	接触	jie1chu4

Note. The bolded letters of the pinyin for the first phoneme and first syllable primes show the primes' phonological overlap with the target word.

PRIMING OF MANDARIN TOT RESOLUTION

Table 2

Number of Correct and Incorrect Responses to Target Questions

	Correct Know		Incorrect Know		Correct TOT		Incorrect TOT		Don't Know	
Experiment	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Experiment 1	24.93	11.24	19.84	9.12	17.64	7.33	4.22	3.01	32.36	14.68
Experiment 2	23.48	12.51	15.65	8.28	19.40	11.02	4.52	3.74	35.94	16.78

PRIMING OF MANDARIN TOT RESOLUTION

Table 3

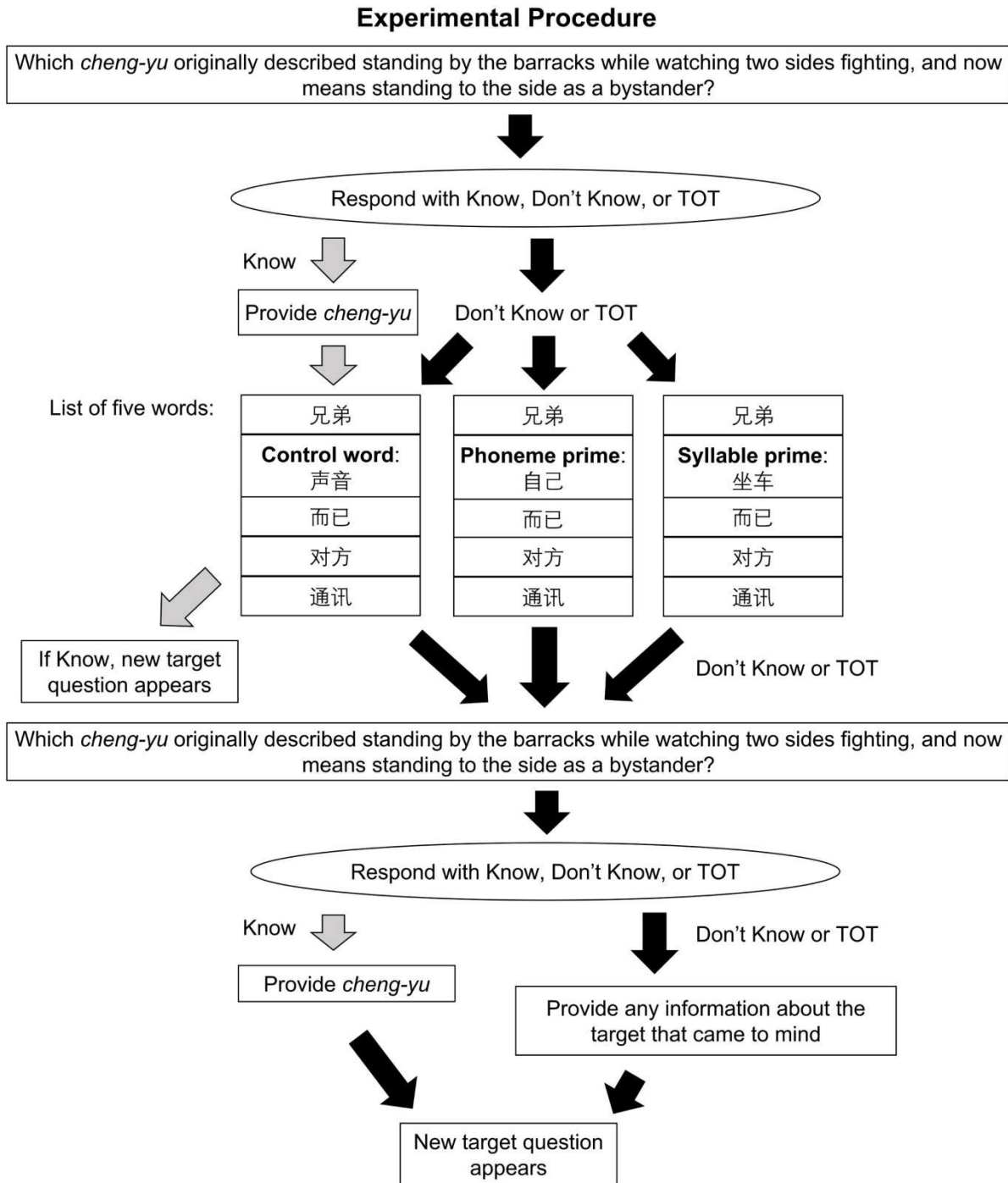
Number of Resolved and Unresolved TOTs by Priming Condition

	First Phoneme		First Syllable		Unrelated	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Experiment 1						
Resolved TOTs	0.71	0.84	0.98	1.12	0.71	0.82
Unresolved TOTs	4.76	2.47	5.16	2.63	5.33	2.36
	First Radical				Unrelated	
			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Experiment 2						
Resolved TOTs			1.35	1.30	1.52	1.83
Unresolved TOTs			8.40	5.30	8.13	4.87

PRIMING OF MANDARIN TOT RESOLUTION

Figure 1

Experimental Procedure for a Single Trial in Experiment 1



Note. Information is shown in English for clarity, but the actual experiment displayed all

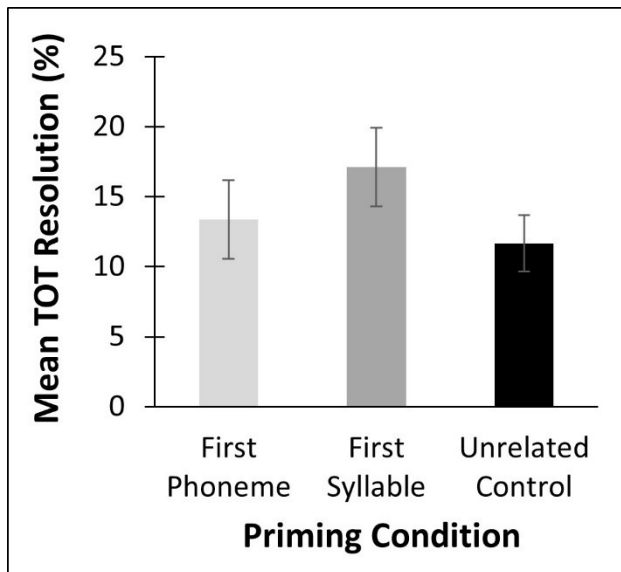
PRIMING OF MANDARIN TOT RESOLUTION

information in Mandarin. Similarly, the bold label indicating the type of word in the second position in the list was not shown during the actual procedure.

PRIMING OF MANDARIN TOT RESOLUTION

Figure 2

TOT Resolution as a Function of Phonological Priming Condition in Experiment 1

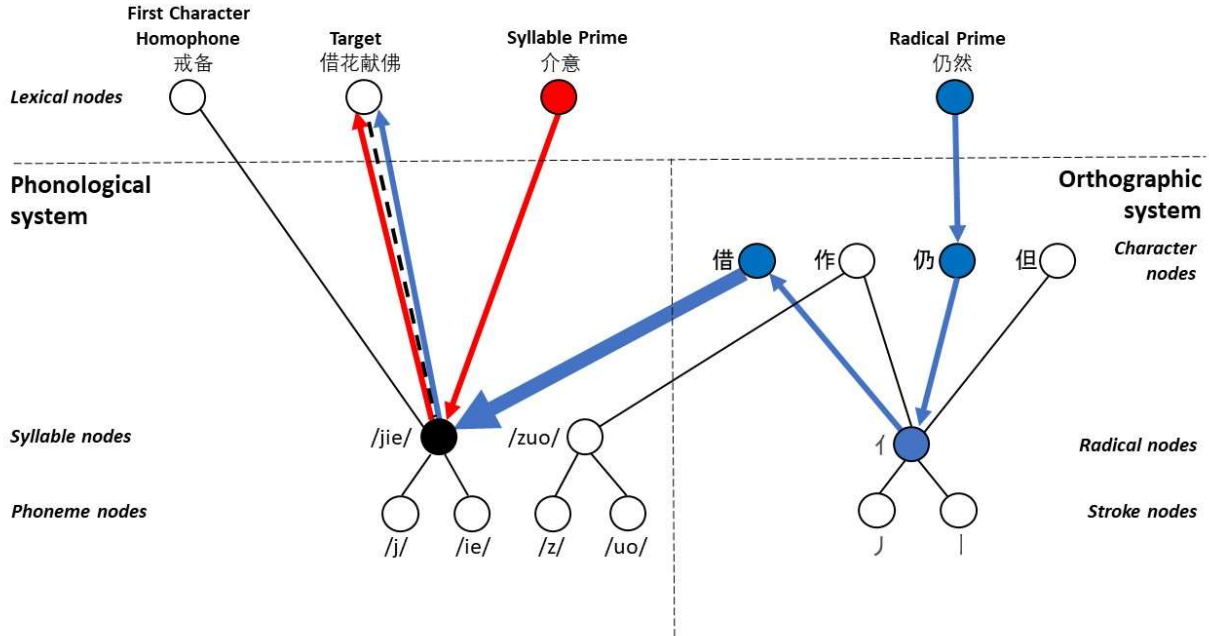


Note. Error bars represent ± 1 SE.

PRIMING OF MANDARIN TOT RESOLUTION

Figure 3

Transmission Deficit Model of Priming Mandarin TOT Resolution



Note. Many nodes are omitted for simplicity, including those representing tone. Arrows show a hypothetical spread of activation, with red arrows demonstrating paths for phonological priming from a first syllable prime and blue arrows demonstrating paths for orthographic priming from a first radical prime. The critical connection for resolving the TOT is shown with a dotted line stemming from the black node. The character-to-syllable connection responsible for the first radical frequency effect is shown via the thickest blue line. Pronunciation in the phonological system is indicated via pinyin.