THESIS

CONTEXT GOT YOUR TONGUE? OVERCOMING TIP-OF-THE-TONGUE STATES VIA CONTEXTUAL CHANGE

Submitted by

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ABSTRACT

CONTEXT GOT YOUR TONGUE? OVERCOMING TIP-OF-THE-TONGUE STATES VIA CONTEXTUAL CHANGE

The tip-of-the-tongue (TOT) state—the feeling of being on the verge of accessing a word that has not yet come to mind—happens to everyone but can increase in frequency as people age or experience certain neurological conditions. Research shows that a TOT state for a given sought-after word will tend to be repeated at a later time if not self-resolved, and that self-resolution reduces the likelihood of a TOT state recurring. Although simply providing people with the target word does not reduce the likelihood of a future TOT recurrence for that word, inducing self-resolution with phonological or orthographic cues does reduce TOT recurrence. An issue is that in real life, a person experiencing a TOT state for a word cannot easily obtain a phonological or orthographic cue to help them self-resolve the TOT state, as there is no third-party supplier of such cues. Based on problem-solving work suggesting that changing one's context (i.e., changing one's surroundings) helps with forgetting fixating ideas to arrive at the solution to a problem (e.g., Smith & Beda, 2020), the present study examined whether contextual change can facilitate TOT self-resolution in older and younger adults. Support for this hypothesis was not found; in both older and younger adults, TOT resolution was no more likely when screen background images changed than when they were reinstated. However, TOT rates decreased from Phase 3 to Phase 5, consistent with new research on increased TOT resolution with continued retrieval attempts, and self-resolution decreased TOT recurrence. Finally, although older adults reported more TOTs than younger adults, older adults also answered significantly more questions.

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Chapter 1 – Introduction

Tip-of-the-Tongue (TOT) States

The tip-of-the-tongue (TOT) state is an experience that nearly everyone has had. It occurs when a word feels right on the verge of access, as if it is about to be called to mind at any moment, but remains elusive. Research suggests that the TOT state is a universal experience, occurring across age groups, languages, and cultures (e.g., Brennen et al., 2007; Elbers, 1985; Schwartz, 1999; Thompson et al., 2005). TOT states have been shown to increase with age (e.g., Burke et al., 1991; Heine et al., 1999; Salthouse & Mandell, 2013), with an increasing number of languages spoken (e.g., Chikamatsu, 2005; Gollan & Acenas, 2004; Schwartz,1999; Thompson et al., 2005), and with certain neurological conditions that lead to word anomia (Ashcraft, 1993; Hamberger et al., 2003; Trébuchon-Da Fonseca et al., 2009; Vigliocco et al., 1999). Research has also shown that TOT states tend to recur (i.e., repeat for the same word) even when the sought-after word has been seen and verified by a TOT experiencer (Warriner & Humphreys, 2008). Given the potential disfluency to language ability and communication that frequent TOT states present, it would be useful to find avenues that people can use to 1) access the desired word when in a TOT state and 2) reduce the likelihood of a subsequent repeating TOT state for the same target word in the future when attempting to access that word. The purpose of the research proposed here is to examine a novel approach to both.

TOT State Resolution

Although TOT states are fairly common, they do not necessarily result in a continued lack of retrieval of the sought-after word. TOT states predict word retrieval imminence, as eventual access to the desired word often follows the TOT state. This eventual access is referred

to as TOT state resolution (see Cleary & Schwartz, 2025, for a review). There are different ways that TOT resolution can occur, such as spontaneously or through cues, or by encountering the word. Research on TOT state resolution has primarily been conducted in two ways: 1) diary studies (e.g., Burke et al., 1991; Cohen & Faulkner, 1986; Gollan et al., 2005; Heine et al., 1999), and 2) in the laboratory (e.g., Cleary et al., 2021; Gollan & Acenas, 2004).

Spontaneous TOT State Resolution

TOT state resolution often occurs seemingly spontaneously (see Cleary and Schwartz, 2025, for a review). That is, the desired word that triggered a TOT state can seem to "pop into mind" at a later time, long after active search efforts have ceased (Cohen & Faulkner, 1986). The majority of work on spontaneous TOT state resolution has come from diary studies, which are well-suited for examining eventual spontaneous TOT state resolution because they can extend over a long time period (whereas a typical laboratory study takes place in under one to two hours).

Diary studies typically entail formal reporting of naturally occurring TOT experiences, which can include inquiry into whether a particular experience was resolved, how it was resolved, the amount of time that passed before resolution occurred, and the properties of the desired word. Burke et al. (1991) found that participants spontaneously resolved 46% - 61% of their TOT states during the duration of their 4-week study, depending on the age group, while Cohen and Faulkner (1985) observed a spontaneous resolution rate of 10% - 23%; however, they only examined TOT experiences with proper names. Despite the reliance on self-reporting methods, which may not fully capture every naturally occurring TOT state (Cleary & Schwartz, 2025), diary studies do provide evidence for the eventual spontaneous access of a desired word in the real world.

Recognition-based TOT State Resolution

Another way TOT resolution might occur is by happening upon the correct target word and recognizing that it is, in fact, the sought-after word. In laboratory investigations of TOT states, spontaneous resolution is more difficult to examine due to the short time frame involved in typical lab studies. Therefore, with such studies, TOT state resolution is commonly examined through target recognition. Many research studies have shown that TOT states are predictive of later target recognition on a multiple-choice recognition test. That is, there is a higher probability of choosing the correct target word from among a set of options following a TOT state than a non-TOT state for an unanswered question or prompt (e.g., Cleary et al., 2021).

As an example of increased likelihood of target recognition following a TOT state, Heine and colleagues (1999) had participants review the definitions of uncommon English words and provide the correct word for each definition. When participants indicated that a target word for a definition was unknown or if they indicated experiencing a TOT state, they were provided with multiple-choice options that contained the correct target word (among incorrect words). Presenting participants with multiple-choice options led to a greater proportion of TOT states being resolved. However, this was not the main focus of the study by Heine et al., and target recognition as a form of resolution aid was provided only during instances wherein participants could still not produce an answer after being presented with both semantic and orthographic cues.

Another example of increased target recognition following a TOT state can be found in a study by Cleary and colleagues (2021). Cleary et al. investigated whether the higher probability of correct recognition that often accompanies TOT states (e.g., Bacon et al., 2007; Salthouse & Mandel, 2013; Schwartz et al., 2000) could be capitalized on in an adaptive testing situation.

They had participants answer general knowledge questions and indicate the presence or absence of a TOT experience whenever failing to retrieve an answer. Participants also decided whether they wanted to be presented with a set of multiple-choice options to choose from regarding the sought-after answer. Choosing to have multiple-choice answers presented came with a point risk: They would gain a point if correct in their multiple-choice answer and lose a point if incorrect. They could avoid the risk and decline a potential penalty to their current points by choosing to move on to the next question without receiving multiple-choice options. In the face of a point loss risk if wrong, participants were able to strategically use the presence of a TOT state to decide when to have multiple-choice answers presented. That is, because the TOT state is associated with later target recognition, participants were able to use it to decide when to receive the multiple-choice options. In this way, the well-known finding of an increased likelihood of target recognition following TOT states has been demonstrated to have utility and practical applications in the real world.

Cue-based TOT State Resolution

In addition to target recognition, TOT states may be resolved via cues such as those based on orthography or phonology (e.g., Gollan & Silverberg, 2001). Orthographic cues refer to the presentation of single or multiple letters of a given word to assist with retrieval. Consider the word *insomnia,* which can be cued as a word fragment with a single letter (*i*-------) or with multiple letters (*ins*----*a*). Orthographic cues are effective in facilitating lexical retrieval (e.g., Massaro et al., 1991), with additional cues increasing the probability of successful word retrieval (Tulving & Watkins, 1973). Such cues may be effective in facilitating successful lexical retrieval for aphasic word-finding difficulties (Hickin et al., 2002).

D'Angelo and Humphreys (2015) used such orthographic cues to induce resolution in participants who experienced repeated TOT states, which significantly improved the likelihood of retrieving a sought-after word. However, cues in written form are not the only ones that can assist with lexical access, as cueing with a target word's phonology also leads to successful word retrieval. To examine the effects of phonological cues on lexical access and TOT state resolution, James and Burke (2000) primed participants with lists of words prior to answering general knowledge questions. The word lists contained at least five words that mapped phonologically onto different parts of the target word for a given question, resulting in increased lexical access while reducing TOT state onset. James and Burke also provided similar phonological cues when general knowledge questions went unanswered, either due to a "don't know" response or a TOT state that went unresolved. Target word retrieval increased significantly following such phonological cues, but only when participants were in a TOT state.

On a similar note, Abrams and colleagues (2003) found support for the critical role that the first syllable plays in phonological cueing, compared to a target word's first phoneme or initial letter in facilitating successful retrieval. They interpreted their findings as suggesting that phonological cues can drive spontaneous resolution, as such cues are typically unknown to TOT experiencers.

Strategic TOT State Resolution

Finally, another potential path to arriving at a TOT state resolution is by engaging more deliberate strategies for trying to arrive at the target word. Such strategies involve continued search efforts such as 1) consultation with external sources (e.g., asking another person), 2) going through the alphabet to try to happen upon the sought-after word's first letter, which might in turn serve as a cue for the target, or 3) generating contextual information such as the location

or circumstance where a target word was last encountered (Burke et al., 1991; Cleary & Schwartz, 2025; Cohen & Faulkner, 1986; Ecke, 1999).

Summary

In summary, TOT states are widely demonstrated to have validity in that they are predictive of eventually arriving at the sought-after target word—a phenomenon referred to as resolution. TOT state resolution has been shown to occur spontaneously in diary studies. It may also occur through target recognition or through effective cuing of the target in laboratory studies. Finally, a person experiencing a TOT state can follow deliberate strategies to resolve the TOT state, such as going through the alphabet to try to encounter the word's first letter or searching the internet using definitions or descriptions to identify the target word (e.g., Cleary & Schwartz, 2025). A goal of the present study is to explore a novel, theory-driven hypothesis regarding how a person might be able to strategically increase the likelihood of arriving at a TOT resolution following a TOT state. Finding ways for people to arrive at a TOT state resolution is an important goal, given that research suggests that a TOT state for a target word is likely to recur on a subsequent occasion when trying to retrieve that same word later on, and that resolving the TOT state on one's own reduces the likelihood of a re-occurrence for that word later on. Thus, the potential benefits of knowing how to put oneself on a path toward TOT resolution are twofold: 1) It can help relieve the momentary word-finding difficulty, and 2) it can help prevent a future TOT state for that same word when trying to access it in the future.

TOT State Recurrence

A growing body of research suggests that when a TOT state occurs for a particular word, there is an increased probability of again experiencing a TOT state when trying to access that same word in the future. Warriner and Humphreys (2008) asked participants to provide the

corresponding word for a given definition. If a TOT state was experienced when attempting to identify the word for a definition, the participant was randomly assigned to either a 10- or 30-second delay and instructed to continue their retrieval efforts. After the delay, the correct answer was displayed. Warriner and Humphreys discovered that the probability of a recurring TOT state was higher when participants were unable to resolve their TOT experiences on their own, and more TOTs recurred for participants who were assigned to longer delay periods to continue retrieval efforts. Fewer recurring TOT states happened when initial TOT states were self-resolved by the experiencer. Furthermore, feedback (seeing the answer) following the TOT experience had no effect in reducing TOT state recurrence. Warriner and Humphreys interpreted their findings as indicating that, during word search efforts, if people do not successfully arrive at the sought-after word on their own, they retain erroneous connections or mental paths to incorrect information in memory that continues to make a future TOT state for that word likely. However, when people retrieve a word on their own, they reinforce the cognitive pathway to it, making future recall more efficient

To further understand why non-self-resolved TOT states tend to recur, D'Angelo and Humphreys (2015) conducted a six-experiment study, which also replicated prior findings (i.e., Warriner & Humphrey, 2008). Self-resolved TOT states were again associated with a decreased likelihood of recurrence, whereas simply seeing the correct answer provided by the experimenter did not decrease the likelihood of a recurrence. Additionally, recurring TOT states were shown to repeat after a short 5-minute delay, and up to one week later for both monolinguals and bilinguals.

D'Angelo and Humphreys (2015) asked another question: If self-resolution is critical to reducing TOT state recurrence, could people be assisted toward self-resolution in a way that does

not involve displaying the answer, but that guides them toward arriving at the target word on their own? D'Angelo and Humphreys examined this by intermittently offering participants orthographic cues. Their findings revealed that, in contrast to merely being shown the answer after an unsuccessful retrieval attempt, resolving the TOT state with the aid of an orthographic cue provided similar benefits as self-resolution in reducing the likelihood of TOT recurrence.

As mentioned before, diary studies have shown that spontaneous resolution for words can happen at a later point in time; however, waiting to spontaneously resolve a TOT state can take an indefinite amount of time in comparison to other self-resolution strategies, like being presented with an orthographic cue. Furthermore, persistent alternates or interlopers retrieved during resolution attempts are typically associated with longer resolution times (Burke et al., 1991; Jones, 1989), adding some degree of risk to just waiting to see if the TOT state will resolve on its own. Thus, having an orthographic cue may be one way to achieve the benefits of self-resolution in reducing TOT state recurrence. However, when one does not know the word in question, one cannot come up with the appropriate orthographic cue on one's own. Thus, an external person (like a clinician working with a person suffering from word anomia) could potentially provide an orthographic cue to a person to help them in arriving at a resolution that will help to reduce the likelihood of a later TOT state recurrence for that target word. However, the orthographic cuing approach is not going to be a practical strategy that people can use in everyday life to achieve resolution and reduced TOT state recurrence. For this reason, the present study explores another possible means of arriving at a TOT state resolution that a person can achieve on one's own while not being able to access the target word. Specifically, the present study will examine whether the tactic of changing one's context (i.e., physical surroundings)

could provide a path toward an increased likelihood of TOT state resolution and thereby a means of reducing the likelihood of a recurring TOT state for that word.

Context-Change as a Potential Strategy for Achieving TOT State Resolution

Although no studies have investigated the possible role of changing one's surroundings in resolving a TOT state, there is a basis for hypothesizing that changing one's surroundings will increase the likelihood of a TOT state resolution. This basis stems from research in a different domain—that of creative problem-solving—which has demonstrated that changing context can facilitate arriving at the solution to a problem for which the answer was previously failing to come to mind. Although arriving at the solution to a problem might seem fundamentally different from arriving at a word, Smith and Beda (2024, p. 13) draw parallels between the two, stating:

> "A so-called incubation effect is said to occur when you put aside a fixated problem, rather than continuing to work consciously on the problem, and after the break, or perhaps during the break, a solution to the problem pops unexpectedly into your mind. A similar experience begins with a retrieval failure of a well-encoded memory: a word or name that seems to be mentally just out of reach may feel like it is on the tip of your tongue (TOT). The unexpected retrieval of the TOT name or word that can occur during or after a break has also been called an incubation effect."

Smith and Beda (2020) investigated the hypothesis that changing a person's context might facilitate access to a problem's solution that would otherwise fail to come to mind. To investigate this, they used a variant of a method that was used by Beda and Smith (2018), who examined how "red herring" words might impede access to a problem's solution in the Remote Associates Task (RAT). The RAT is a commonly used measure of creative problem-solving that

consists of three words presented simultaneously, which can be unified by a single word (i.e., the solution) to form a compound word or common phrase (Bowden & Jung-Beeman, 2003). For example, for the triad COTTAGE-SWISS-CAKE, the answer *cheese* unites the triad in that it combines with each word to form *cottage cheese*, *Swiss cheese*, and *cheesecake,* respectively. Beda and Smith (2018) showed that red herring words (words intended to lead the participant down the incorrect path, away from rather than toward the correct answer) reduced the likelihood of participants arriving at the correct answer for any given triad. Beda and Smith paired such red herring words together with RAT problems. For example, red herring words for the COTTAGE-SWISS-CAKE triad consisted of: COTTAGE-hut, SWISS-chocolate, CAKE-icing. Once the red herrings for this triad are learned, participants would become fixated on those red herring words when attempting to solve that specific RAT triad at test.

To examine their hypothesis about context-change, Smith and Beda (2020) followed up on Beda and Smith's (2018) red herring study using an alternative method to their original paradigm: only red herring words were superimposed on specific background contexts and later retrieved to strengthen their association with their respective contexts. For example, the aforementioned red herring triad "hut," "chocolate," and "icing" would be superimposed over a unique image of a scene on the computer screen, such as a desert. That background scene image served as the context. Participants encoded the red herring words onto their respective backgrounds before practicing retrieving those words through a cued recall task. In the cued recall task, a participant would be shown a desert scene and tasked with retrieving and writing down the red herring words that were associated with that desert context. Following this initial training on the red herring clue stimuli, participants then attempted a set of RAT problems twice. During the first RAT test, all problems were superimposed on the same context as the red herring

words. On the second RAT test, some triads were superimposed on either a unique background context (i.e., one that did not match the red herring context) or the same context as the red herring words. Participants were better at solving the RAT triads when the background context had been changed than when the background context was used with the red herring cues. Thus, changing the context seemed to reduce access to incorrect representations brought on by the red herring cues. The converse of this idea is that maintaining the same context increases the likelihood that people will fall prey to fixation effects (getting stuck on a particular set of red herring words in a way that impedes access to the correct word). Other studies also found evidence for this type of context-dependent fixation effect (Smith & Beda, 2018; Gauselmann et al., 2025). Thus, it appears that a fixation on incorrect or unproductive words (or, put differently, competition or interference from cued incorrect or unproductive words) can be reduced when there is a change in context, allowing novel, potentially more productive ideas or solutions to be generated.

Changing or shifting one's context to forget a fixated idea is similar to the location-updating effect, which refers to the finding that memory representations become less accessible when one shifts their spatial context, such as passing through a doorway, compared to when no such contextual shift occurs (Radvansky & Copeland, 2006). An explanation for this diminished accessibility of memory representations stems from Event Segmentation Theory (EST). The EST proposes that people experiencing ongoing activities segment them into discrete events and that this perceptual processing leads to inferences of the near future (Zacks et al., 2007). These future inferences about the state of the world are guided during perceptual processing by event models, which are sets of representations of the current ongoing activities being perceived by the observer. The EST also posits that inferences are evaluated by an error detection mechanism that

compares inferences to the unfolding events in the world and, when prediction errors are high, event models are updated. The updating process results in resetting representations in a given event model to achieve stability (i.e., less prediction error). Stability is perceived by the observer as an event, while a change in the event is perceived as an event boundary marking the end of a particular event and the beginning of a novel one (Radvansky & Zacks, 2017; Swallow et al., 2011; Zacks et al., 2007). Once a novel event model is active, information retrieval for the active model is made more accessible, while access to information from previous event models is diminished. That is, the updating of event models adversely impacts memory retrieval for prior models, which can occur when one makes a shift in spatial location or context (Radvansky et al., 2011).

Applying the EST and location updating effect to context-dependent fixation (or to the benefits of changing context on creative problem-solving), when one learns incorrect solutions to a problem in a particular context, it would make sense that reinstatement of said context would allow for greater accessibility to red herring memory representations and less access to representations for novel solutions (e.g., Smith & Beda, 2020). Within the EST framework, sensory input from the environment, along with guidance from event models, is used to formulate predictions (Zacks et al., 2007). During learning, the visual background readily predicts red herrings (as verified and reinforced by retrieval practice and feedback). When context changes, event models update, making previous red herring words less accessible during ongoing problem-solving, facilitating retrieval of other representations that lead to correct solutions.

Similar to how learned fixation or competition from distractor stimuli can inhibit successful problem-solving (e.g., Smith & Beda, 2020), recurring TOT states have been

theorized to involve learned incorrect pathways among word representations in a way that results in a greater likelihood of a TOT state being repeated for a given target word (D'Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). D'Angelo and Humphreys (2015) specifically argued that recurring TOT states stem from implicit error learning; that is, repeated TOT states repeat because of the incorrect activation in language production that occurs during retrieval attempts, so when the same retrieval cue for a target word is reintroduced (e.g., a general knowledge question), one's prior activation pattern is reinstated, resulting in a repeated TOT state. This is somewhat analogous to Smith and Beda's (2020) study of maintaining vs. changing the context from the time of learning (and making accessible) incorrect information to the time of trying to retrieve the answer to a RAT triad. Additionally, context could serve as a cue to reinstate such patterns of activation or, if context is changed, could allow for the forgetting of such patterns.

Present Study

The current study sought to examine the hypothesis that changing one's context following the onset of a TOT state would increase the likelihood of a TOT state resolution. The present study also examined the hypothesis that by increasing the likelihood of a TOT state resolution, changing one's context following a TOT state would also decrease the likelihood of a recurring TOT state. If recurring TOTs reflect learned activation patterns during language production, as D'Angelo and Humphreys (2015) argued, then such activation patterns should be reinstated when context is reinstated, much like how fixated ideas can be reinstated (Smith & Beda, 2020). Put differently, if word access is being impeded by competition from other word representations (or word component representations, such as phonology or other components) and hindering access to the target word, then changing one's context might be expected to create a different set

of cues that could lead to a different set of competitive word activations in the mind. Accordingly, altering context may increase the probability that the sought-after word will gain access to awareness through an increased ability to compete for access successfully.

Similarly, based on the theoretical implications from the EST (Zacks et al., 2007) and findings from research on the location-updating effect (Radvansky & Copeland, 2006), resolution for TOT states should be more likely when a recurring TOT state unfolds in a novel context, as event models should update, resulting in the resetting of representations (i.e., diminishing accessibility to prior retrieved representations for initial TOT states). Additionally, context-induced resolutions should provide comparable protection, much like self-resolutions, from recurring TOT states. As with other recurring TOT studies and research on context-dependent memory, it is not expected that TOT states will be guaranteed to recur when context is reinstated, but there should be a greater likelihood of TOTs recurring when they unfold in a reinstated context, more so than when the context is novel. The reduced likelihood of recurring TOT states is expected to be similar to that of orthographic cue-based resolution and self-resolutions, as observed from previous work by D'Angelo and Humphreys (2015).

Finally, because older age is one factor known to increase the frequency of experiencing TOT states (see Cleary & Schwartz, 2025, for a review), older adults may benefit more from a practical method of resolving TOTs and preventing their recurrence, as they experience more frequent TOT states than their younger counterparts. Thus, it is important to investigate whether the proposed method of changing context will also benefit older adults. There is reason to hypothesize that it will. Symeonidou et al. (2026) found that older adults' memories for information are associated with the context in which that information was presented, the same way that younger adults' memories have been shown to be in studies of memory and context

reinstatement. If reinstating the context in which a piece of information was presented can cue older adults' memories for the information that was learned in that context, then it is conceivable that reinstating the context in which a TOT state occurred could also increase the likelihood of a recurring TOT state for the target word in question analogously to how reinstating the context in which red herring cues prevented access to a problem's solution in Smith and Beda's (2020) study of young adults. Thus, the present study additionally investigated the hypothesis that older adults would benefit from context change, both in terms of increasing the likelihood of TOT state resolution and in terms of reducing the likelihood of TOT state recurrence

Chapter 2 – Experiment

Methods

Participants

Based on a power analysis using G*Power for a medium effect size (Cohen's $d = 0.40$), with 95% power and an alpha level set at .05, an approximate sample size of 168 was the target goal for recruitment, in order to obtain 84 participants per age group being examined. Although typical effect sizes for location updating effects are larger, the decision to base power on a Cohen's *d* of 0.40 was made due to the greater similarity between the current study's method of context change and that of previous research (e.g., Smith & Beda, 2020), since context was changed abruptly rather than gradually. Despite this overlap in contextual change with related work, this target sample size was necessarily an approximate estimate, as shifts in context have not been applied to TOT state resolution or recurrence.

A total of 169 participants were recruited via the Prolific platform and compensated at a $12/hour rate in accordance with Prolific guidelines and recommendations. Participation in the study took approximately 60 minutes. Due to early experiment termination, failure to provide an age during the demographic questionnaire, providing an age that could not be categorized as young or older adults, allowing the experiment program to time out for the majority of trials, failing to complete at least 70 trials, or failing to read instructions when answering general knowledge questions, 19 participants were excluded from analyses. Approximately half of the 150 participants ($n = 72$) were young adults (18-26 years), with an average age of 22.18 years ($SD = 2.49$), and the other half ($n = 78$) were older adults (60+ years) with an average age of 69.86 ($SD = 3.98$). Recruitment of both age groups was restricted to the United States and Canada due to the North American cultural specificity of the current study's TOT-inducing

pointers (general knowledge questions). Additionally, recruitment was restricted to those with native-level fluency in English (for gender and ethnic identity see Table 1).

In terms of educational background, the average years of education for young adults was 14.40 years, while the average for older adults was 15.76 years. Another piece of demographic information collected concerned whether participants identified as a native English speaker or not. For young adults, 81.94% reported being a native English speaker, and 13 participants did not. Those who did not report being a native English speaker reported speaking English for an average of 14.46 years. For older adults, 92.31% reported being a native English speaker, while 6 participants did not. Those who reported not being a native English speaker reported speaking English for an average of 46.83 years.

Table 1. Demographic information on reported participant gender and ethnic identity.

Reported Identity	Young Adults		Older Adults		Overall	
	n	%	*n*	%	*n*	%
Gender Identity						
Female	35	48.61	50	64.10	85	56.67
Male	35	48.61	27	34.62	62	41.33
Non-binary/ agender/third gender	0	0.00	0	0.00	0	0.00
Prefer not to say	2	2.79	0	0.00	2	1.33
Ethnic Identity						
Caucasian/White (non-Hispanic)	39	54.17	83	80.77	102	68.00
Black (non-Hispanic)	7	9.72	5	6.41	12	8.00
Asian or Pacific Islander	17	23.61	4	5.13	21	14.00
Native American or Alaska Native	0	0.00	0	0.00	0	0.00
Hispanic	3	4.17	2	2.56	5	3.33
Prefer not to say	1	1.39	0	0.00	1	0.67
Other	0	0.00	3	3.85	3	2.00
Multiple ethnicities	5	6.94	1	1.28	6	4.00

Note. For gender identity, the full sample's percentage falls slightly short of 100% due to one of the older adult participants leaving the gender identity question unanswered.

Materials

The experiment was programmed using PsychoPy in conjunction with the Prolific platform to facilitate online participant recruitment, and Pavlovia as a repository for data collection and storage. The general knowledge questions used in the current study, were

originally developed by Nelson and Narens (1980) but updated by Tauber and colleagues (2013) and consisted of a similar set of questions used in prior TOT research (e.g., Cleary & Claxton, 2015; Cleary et al., 2020; Huebert et al., 2023).

Images for background contexts were sourced from Pixabay (pixabay.com), which are covered by either a Creative Commons Zero (CC0) license for works published before January 9th, 2019, or Pixabay's general Content License. The images chosen for the study featured minimal to no people (e.g., less than 2 people in the background of an image) and were of similar quality to one another. For the initial context encoding phase, 80 images served as backgrounds with statement versions of 80 general knowledge questions superimposed over them. For example, instead of "what is the breed of cat with blue eyes?" the statement "there is a breed of cat with blue eyes" was overlaid on its own unique background (see Figure 1). Furthermore, each statement was displayed in white, bolded 48-point Arial Nova font with a black outline set to 2.25 points, overlaid on a white translucent rectangle (50% transparency) to ensure readability across the varying context stimuli while maintaining participant visibility of each context. Instructions or prompts on the screen made use of the same procedures but varied in font size (24 – 32 points) and were centered at the top of the screen. These stimuli were also created on PowerPoint and saved as JPGs prior to their use in the PsychoPy program.

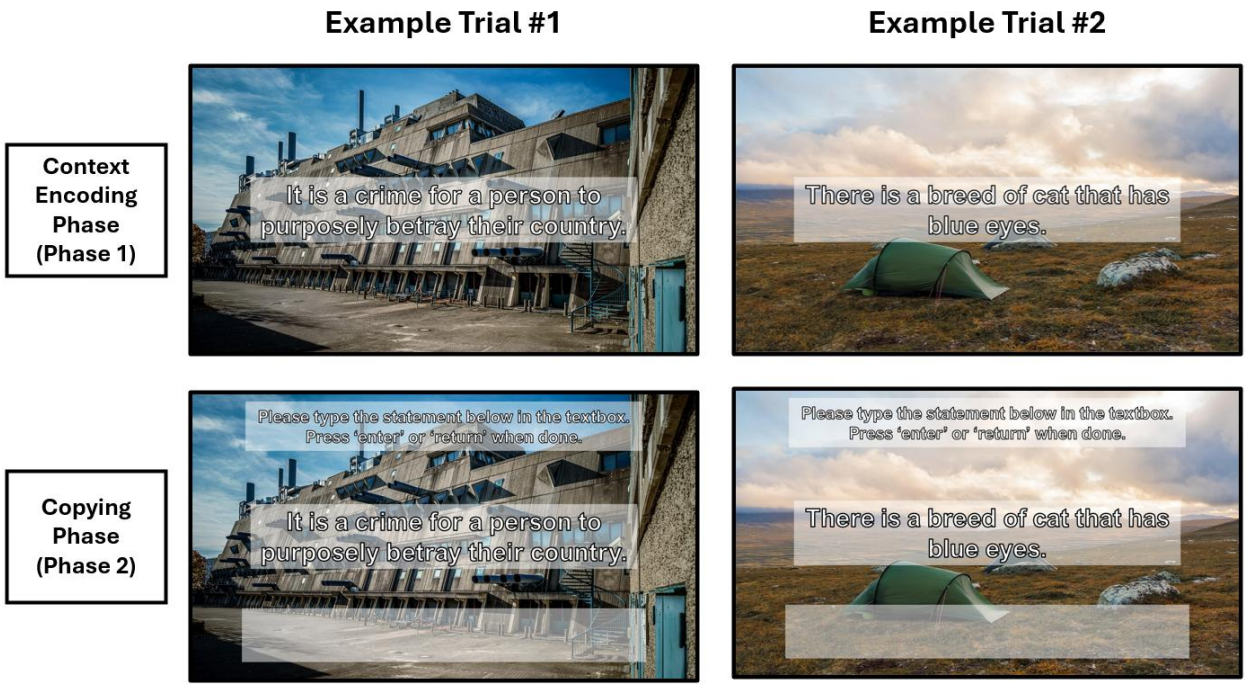

Figure 1. Example trials of background-image and statement combinations were presented to participants during the context-encoding phase. During the copying phase, the background images were presented along with instructions to type a given statement--original images derived from Pixabay.com.

For the first general knowledge question test, the questions themselves were presented rather than in the statement form. Each question was superimposed in the same position and with the same font over the same 80 background images from the first phase (see Figure 2). In the next phase, 40 general knowledge questions were superimposed over novel, never-before-seen background contexts for a total of 40 images, while the other 40 were superimposed on the same background contexts as before (see Figure 2). General knowledge questions whose contexts were changed in the aforementioned phase were selected at random, and an alternate version of the experiment (for counterbalancing purposes) changed the context for the opposite set of questions (i.e., in the second version of the experiment, the context was changed for the 40 general knowledge questions whose context was not originally changed during the first version of the

experiment). For the final general knowledge question test, all questions were superimposed over a neutral white background (see Figure 2).

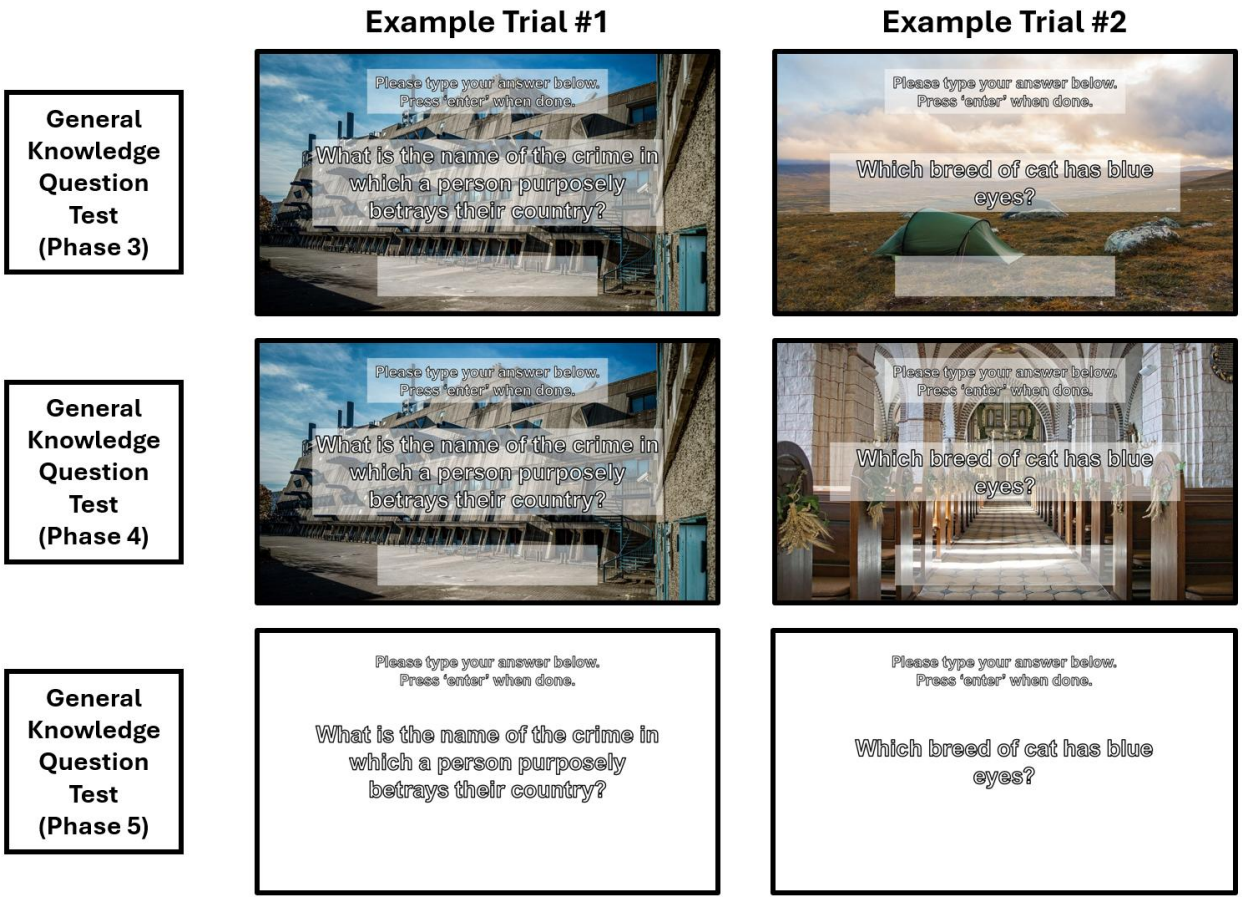

Figure 2. Example trials for phases with general knowledge questions. In Phase 3, all questions were superimposed over the same background images as in prior phases. In Phase 4, half of the background images remained the same for 40 questions, while the other half were novel for the other 40 questions. In Phase 5, all questions were overlaid on a white neutral background.

Along with the materials mentioned earlier, an additional set of images comprising the outlines of U.S. states and South American countries was sourced from GIS geography (gisgeography.com) and was superimposed over a white background in the same PsychoPy program. These materials were used for the filler task placed in between each general knowledge question test.

It should be noted that the original design for this study consisted of 120 general knowledge questions, 180 context images, and was self-paced; however, after piloting with 8-10 young adults, the set of stimuli was cut down from 120 questions to 80 and from 180 context images to 120 due to the average completion time exceeding 60 minutes, which persisted even with time limits imposed on each trial. When reducing the set of items, general knowledge questions and context image pairings were selected at random for removal.

Design

Participants completed five phases. (1) In the *context-encoding phase*, participants studied 80 statement versions of the general knowledge questions, each overlaid on their own unique background image. Each statement and background pairing was presented to participants for 3 seconds each. The purpose of this phase was to create an association in participants' minds between each later presented general knowledge question's terms and a particular background context, and follows from the method used by Smith and Beda (2020). Although some research suggests that fluency or familiarity with the question terms can influence the likelihood of a TOT state (e.g., Lee et al., 2023; Metcalfe et al., 1993), exposure to these statement versions is not expected to influence TOT recurrence, as previous research suggests that alternative versions of TOT-inducing items do not affect recurrence (Oliver et al., 2019). (2) Next, during the *copying phase*, participants were presented with the same statement-background image pairings as before and were asked to copy as much of the statement as they could within a 9-second time limit while disregarding exact spelling and punctuation, as some statements were longer than others. (3) Participants then encountered 80 general knowledge questions for the first time, each superimposed on their specific associated background images from the previous two phases. During this phase, participants made attempts to answer each question within an 8-second time

limit. (4) In this next phase, participants attempted to answer the same 80 questions again, with 40 questions presented over the same background images as before and the other 40 with novel backgrounds. (5) Finally, participants engaged in a third attempt at answering the same set of questions, this time each presented on a neutral white background. Every general knowledge question test consisted of 3 parts wherein participants made their initial attempt to answer a given question, were prompted to indicate whether they were experiencing a TOT state for the target answer, and then were given a second attempt to answer the question by providing the correct answer or any partial information about the target answer (see Figure 3). Each attempt at answering the question and TOT prompts had a time limit of 8 seconds, which participants were made aware of during the instructions phase prior to beginning the first general knowledge question test. Additionally, between each general knowledge question test, participants completed a filler task consisting of naming U.S. states and South American countries.

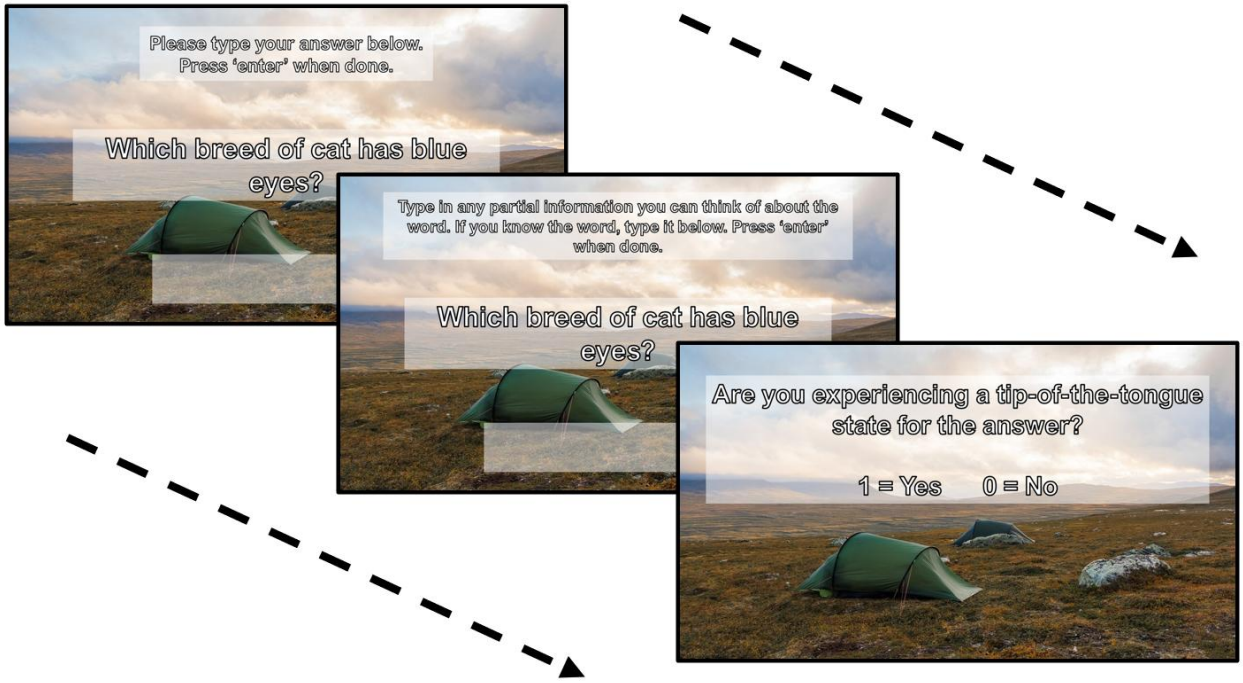

Figure 3. Graphical depiction of TOT indication prompt following a general knowledge question, as well as a prompt for providing partial information for a sought-after word.

A mixed design was employed in which Phase 4 Context (reinstated vs. changed) was a within-subjects variable and Age Group (younger vs. older adults) was a between-subjects (quasi-experimental) variable. These independent variables were examined to determine if they exerted effects on two different dependent variables of primary interest: 1) Phase 4 TOT resolution rates, and 2) Phase 5 TOT recurrence rates. The primary hypotheses under investigation with this design are 1) Changing context in Phase 4 will increase TOT resolution rates compared to reinstating context in Phase 4 in both younger and older adults, 2) Self-resolving TOTs in Phase 4 will increase the likelihood that the answer will be retrievable later on in a neutral context (Phase 5) among both younger and older adults, and 3) changing context in Phase 4 will increase the likelihood of retrieval in Phase 5 of targets for which TOTs occurred in Phase 3.

Procedure

The program began with a welcome screen with general instructions for the experiment and what participants could expect:

> *Welcome to our study on human memory! In this study, you will be shown various statements, each overlaid on its own unique background image. Then you will be presented with the same statements overlaid onto their unique background images and this time, you will be asked to copy the statement by typing it into the provided response box.*
>
> *Later in the experiment, you will be shown questions that are each overlaid onto their own unique background image. You will be asked to try to answer each of these questions, then, if you had not correctly identified the answer, you will be asked to indicate if you feel that the answer is on the tip of your tongue—on the verge of coming to mind. Afterwards, if you had not correctly identified the answer to the question the first time, you will be prompted to give any information you can think of regarding the answer to that question. You will then complete a geography task before continuing to answer more questions (this pattern will be repeated twice).*
>
> *Press the 'Spacebar' to continue.*

Once the spacebar key had been pressed, the next set of instructions were displayed:

> *In the following phase, you will be presented with general statements that are each overlaid onto a background image (e.g., the screen will have a background image of an office lobby while also displaying the following statement over it: "A good chef knows how to prepare a salmon-based dish.")*

Each statement will have its own unique background image (i.e., statements will not share any background images). Each statement will be displayed on the screen for 3 seconds before proceeding to the next one.

Press the 'Spacebar' to begin.

After pressing the spacebar key, participants were shown 80 statement versions of the general knowledge questions one at a time (e.g., "There is a breed of cat that has blue eyes" was displayed instead of "Which breed of cat has blue eyes?"), each was superimposed over its own unique background image. Each statement-background image pairing was displayed on the screen for 3 seconds with a 0-second interstimulus interval in between presentations for each statement-background combination. After all pairings were shown to participants (in a randomized order), the following instructions appeared:

You will see a series of background images; each paired with a unique statement. Your task is to simply copy the statement by typing it into the provided response box. Do not be too perfectionistic here. That is, do not worry about copying the exact capitalization or spelling as long as you copy as much of the statement as possible before your time is up. You will have 9 seconds to copy the statement and submit your answer. This process will repeat for each image and statement pair.

Press the 'Spacebar' to begin.

After pressing the space key, participants proceeded with copying each of the 80 statements within a 9-second time limit per statement. After completing the copying phase, participants were given the following instructions for the first general knowledge question test and were

provided with a definition of a TOT state, which has been used in prior research (e.g., Cleary, 2019; Cleary et al., 2021). The instructions were split into two parts for ease of reading:

> *You will now begin a test phase that consists of answering various questions. Each question will be displayed over its own unique background image. You will type your answer in the provided response box and press 'Return' or 'Enter' to submit it and move on. If you do not know the answer to a question, you can simply press 'Return' or 'Enter' to move on. Next, you will be asked whether you are experiencing a tip-of-the-tongue state or not.*
>
> *A tip-of-the-tongue state is defined as occurring when you feel as if it is possible that you could recall the target answer, and you feel as if its recall is imminent. It's as if the answer is on the tip of your tongue, about to be recalled, but you simply cannot think of the word at the moment.*
>
> *Press the 'Spacebar' to see the next set of instructions.*

After pressing the spacebar key, participants were presented with the second half of the instructions:

> *After indicating whether you are in a tip-of-the-tongue state or not, you will be given a second chance to answer the question. If you cannot answer the question at this time, then you should provide any available details or partial information about the word you are trying to recall (e.g., its first letter, how it sounds, number of syllables, etc.). If no details can be recalled, then you can simply press 'Return' or 'Enter' to continue with the next question. Each prompt will have a time limit of 8 seconds. This process will repeat for each question.*

Because we are investigating tip-of-the-tongue states and factors that might help people to overcome them, we ask that you refrain from searching (using external sources) for any of the answers to these questions as you attempt to answer them. If you do that, you will be depriving yourself of the potential opportunity for one of our methods to allow you to overcome the tip-of-the-tongue state and think of the word on your own. If you are curious about the answer, please wait until the experiment is over, as we will provide all answers to each question via an external link.

Also, for each question, please do not sit and dwell on it—if the answer doesn't come within a few seconds, just keep moving along; you will have other opportunities to try to answer it again.

Press the 'Spacebar' to begin answering questions.

The first general knowledge question test provided participants with an 8-second time limit to provide an answer for their initial attempt, then another 8-second time limit to indicate whether they were experiencing a TOT state for the target answer or not, and an 8-second time limit for their second attempt to provide the answer (or to provide any partial information regarding the target answer). To reduce the length of the experiment and reduce participant fatigue, any question that was answered correctly during the initial attempt skipped the TOT indication prompt and the subsequent second attempt/partial information prompt and moved on to the next question. Any question that was answered correctly during this 3rd phase was programmed not to repeat in phases 4 and 5. After completing the first general knowledge question test in Phase 3, participants were presented with instructions that outlined the details of the state and country naming task. Participants were informed that they would be presented with the outlines of various states in the U.S and countries in South America, and that they would be

tasked with identifying these states and countries. The state and country naming task took approximately 1-2 minutes for participants to complete. Upon completion of this, participants continued to answer general knowledge questions in Phase 4, but 40 of the general knowledge questions were superimposed on novel contexts, while the other 40 were superimposed on the same contexts as before. Participants then underwent the state and country naming task once more before being given a final attempt at answering more general knowledge questions (the same questions that they were presented with during Phase 4). During this last attempt in Phase 5, each question was superimposed over a neutral white background. As with Phase 3, in Phases 4 and 5, participants were given a time limit of 8 seconds during their initial attempt to answer a given question, 8 seconds to indicate whether they were experiencing a TOT state, and 8 seconds during their second attempt (or to provide partial information about the target answer).

After completing the experiment, participants answered a demographic questionnaire in PsychoPy, which asked for information about age, race/ethnicity, gender identity, education level, and Native English fluency level. After completing the questionnaire, participants were thanked for their participation prior to the experiment's conclusion. After the PsychoPy program ended, a dialog box informed participants that they had completed the experiment and survey portion of the study and that clicking "OK" would redirect them to a debriefing form, which would contain the Prolific completion link for their payment for participation. Once participants finished reading the debriefing form, they were provided with the Prolific completion link and a link to a document containing the answers to each general knowledge question.

Chapter 3 – Results

Data Coding and Classification

Before data analysis, typed responses for general knowledge questions from Phases 3 to 5 were manually coded for retrieval success versus failure. Trials were considered instances of target-word retrieval success whenever participants provided the exact spelling of any of the correct or alternate answers and cases wherein participants made misspellings that would otherwise indicate the correct answer (e.g., if the answer to a question was “Versailles”, then the following was considered correct: “versalles”, “versailes”, “verci”, “versai”, and “versi”). Trials were classified as instances of target-word retrieval failure when an incorrect answer was typed that contained no accurate partial information about the answer (e.g., “puppy” instead of “mongoose”) or when an answer was left blank. Trials were categorized as instances of correct partial identification when the typed response during the prompt for answering a question again/partial target information contained the correct letter or multiple correct letters for the answer, the answer’s sound (phonology), the correct number of syllables of the answer, or any information that related to the target that a participant provided (e.g., “it is near Nepal”). Although trials were automatically classified as a TOT vs. non-TOT response for each general knowledge question by the PsychoPy program (because participants responded by pressing 1 for yes or 0 for no), trials were manually coded to indicate which TOT reports fall into the categories of target-word retrieval failure vs. correct target-word partial information vs. target-word retrieval success, as the primary interest in the present study concerned instances of outright target-word retrieval failure where partial target information fails to be identified. Trials were additionally manually coded according to whether a reported TOT state for a given general

knowledge question on the first test was resolved on the second test or not, whether the question itself was superimposed over a novel context or a reinstated context during the second test, and whether questions for which TOT state resolution occurred on the second test led to successful retrieval on the third test.

Additionally, for all analyses and descriptive statistics calculations, participants who were missing data were excluded (e.g., if a participant did not report experiencing any TOTs during any of the context conditions, they were excluded from analyses and descriptive statistics calculations for TOT rates per context condition).

Rate of Answering General Knowledge Questions

Across age groups, participants ended up successfully answering a little over one-third of the general knowledge questions (M = .35, SD = .21). Further examination of differences between age groups required the use of Welch's t-test due to a violation of normality for both young $W(72) = .96$, $p = .037$ and older adults $W(78) = .96$, $p = .009$, and due to a significant Levene's test of equality of variances $F(1, 148) = 7.47$, $p = .007$. Results indicated that younger adults significantly answered fewer questions on average (M = .22, SD = .16) than their older counterparts (M = .42, SD = .22), $t(142.09) = -4.41$, $SE = 0.03$, $p < .001$, Cohen's $d = -0.72$. That is, older adults correctly answered more general knowledge questions in comparison to younger adults.

It is an established finding that as age increases, so does the occurrence of TOT states (see Cleary & Schwartz, 2025, for a review), which has been interpreted as indicating an increased frequency of retrieval failures in older age (e.g., Shafto et al., 2007). From this perspective, one might expect greater retrieval failure for older adults that manifests as fewer general knowledge questions answered; however, older adults in the current study answered a

greater proportion of questions compared to their younger counterparts. While this may be due to generational differences in knowledge-bases between the two age groups, the difference raises the possibility that any increased TOT rates for older compared to younger adults reflect a form of retrieval success rather than failure. For example, Gollan and Brown (2006) argued that TOT states should be viewed as instances of retrieval success rather than failure, going so far as to argue that when computing TOT rates, the denominator should be the number of correct retrievals plus the number of TOTs, rather than the more typical number of non-TOT retrieval failures plus TOT retrieval failures. Thus, the fact that older adults successfully answered more questions than younger adults provides grounds for arguing that any increased rates of reporting TOTs among older adults reflect the increased knowledge-base of answers to the general knowledge question pool compared to the younger adults.

As for why older adults should have a larger knowledge-base of answers to the general knowledge question pool compared to younger adults in the first place, the original set of 300 general knowledge questions developed by Nelson and Narens (1980) was based on answering norms of young adults enrolled in higher education from approximately 46 years ago. The updated norms by Tauber and colleagues (2013) were selected based on a young adult sample also enrolled in higher education, and prior TOT research made use of a subset of 80 general knowledge questions based on their probability of retrieval failure while also not being excessively difficult and thus more likely to induce a TOT state (e.g., Cleary & Claxton, 2015; Cleary et al., 2020). This question subset may have been a set of questions more readily available in older adults' knowledge-base, allowing older adults to be able to more readily answer the current study's general knowledge questions compared to their younger counterparts. Still, together with the pattern that our older adults also report more TOT states than younger adults

(next section), these patterns are consistent with the argument of Gollan and Brown (2006) that TOT states are best viewed as instances of retrieval success rather than failure (that is, the TOT state indicates having access to *something* in memory as opposed to nothing at all).

Rate of Reporting TOT States

As the current study's interest concerns TOT states that were accompanied by complete retrieval failure (i.e., not answered correctly at all during an initial attempt or second attempt), TOT rates were calculated as follows: TOT Rate = #TOTs/(#TOTs + #non-TOTs | retrieval failure). Of central interest to the present study is whether older adults had higher rates of TOT reports than younger adults, consistent with prior research (e.g., Burke et al., 1991; Cleary & Schwartz, 2025; Shafto et al., 2007).

A 3 (Test Phase: Phase 3, Phase 4, and Phase 5) x 2 (Age Group: young adults and older adults) mixed-measures ANOVA revealed a significant overall effect of Test Phase on TOT rates $F(1.72, 254.32) = 32.30$, $MSE = 0.47$, $p < .001$, $\eta_p^2 = .18$. Due to a violation of the assumption of sphericity, as indicated by Mauchly's test $\chi^2(2) = 0.84$, $p < .01$, degrees of freedom were estimated via Greenhouse-Geisser correction ($\varepsilon = .86$). Results revealed that Phase 3 TOT rates were significantly higher ($M = .30$, $SD = .22$) than those from Phase 4 ($M = .24$, $SD = .24$), $t(148) = 5.19$, $SE = 0.01$, $p < .001$, Cohen's $d = 0.29$. Similar to this pattern, Phase 4 TOT rates were significantly higher than those from Phase 5 ($M = .20$, $SD = .25$), $t(148) = 3.34$, $SE = 0.01$, $p = .003$, Cohen's $d = 0.15$. Also, Phase 3 TOT rates were significantly higher than those in Phase 5, $t(148) = 6.82$, $SE = 0.03$, $p < .001$, Cohen's $d = 0.43$ (all post-hoc comparisons were employed using a Bonferroni correction).

A significant main effect was also found for Age Group, $F(1, 148) = 5.42$, $MSE = 0.78$, $p = .021$, $\eta_p^2 = .04$, with older adults experiencing more TOT states than young adults.

However, no significant interaction was found between Test Phase and Age Group, $F(1.72, 254.32) = 0.85$, $MSE = 0.01$, $p = .414$, $\eta_p^2 = .01$.

Taken together, participants experienced a greater number of TOT states during the initial general knowledge question test in Phase 3, which decreased over time during later tests, and older adults continued to experience TOT states at a significantly higher rate than young adults (see Figure 5).

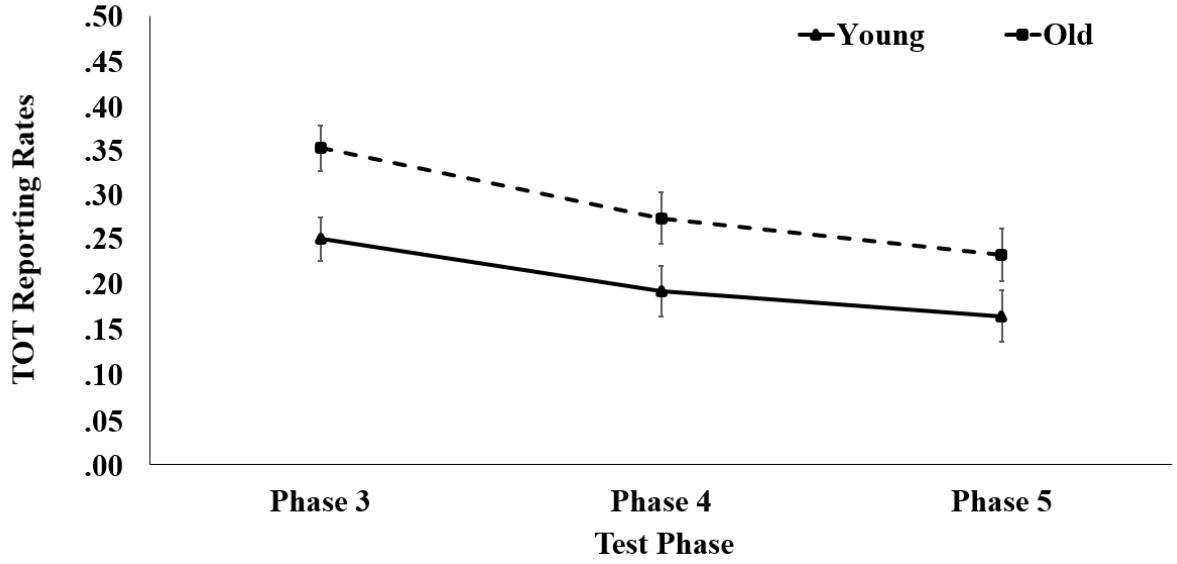

Figure 5. Mean TOT Reporting Rates as a function of Test Phase Conditions. Older adults experienced a greater amount of TOT states across each test phase compared to younger adults. Both age groups experienced a decrease in TOT states over time. Error bars represent standard errors.

Rates of TOT State Recurrence

Another point of interest in the current study is that of TOT recurrence. Rates for TOT recurrence were calculated based on Phase 3 TOT states repeating later in Phase 4 and Phase 5: (p[Phase 4 TOT State] | Phase 3 TOT State) and (p[Phase 5 TOT State] | Phase 3 TOT State), respectively. A 2 (TOT Recurrence Phase: Phase 4 and Phase 5) x 2 (Age Group: young and older adults) mixed measures ANOVA was conducted to examine differences in recurrence rates

between phases and age groups, as well as any potential interaction effect. Results indicated a significant main effect of TOT Recurrence Phase $F(1, 141) = 15.42$, $MSE = 0.24$, $p < .001$, $\eta_p^2 = .10$. In Phase 4, participants experienced a significantly higher rate of TOT recurrence ($M = .36$, $SD = .28$) compared to Phase 5 ($M = .30$, $SD = .29$). No significant main effect of Age Group was found $F(1, 141) = 0.77$, $MSE = 0.11$, $p = .382$, $\eta_p^2 = .01$. No significant interaction between TOT Recurrence Phase and Age Group was found either $F(1, 141) = 0.84$, $MSE = .01$, $p = .843$, $\eta_p^2 = .01$.

Thus, repeating TOTs for the same target word decreases over time, as evident from a significant decrease in the rate of Phase 3 TOT recurrence from Phase 4 to Phase 5. Additionally, younger and older adults did not differ in their experience of TOT recurrence rates. Specifically, older adults did not experience more recurring TOT states than their younger counterparts, indicating that there is not necessarily an increase in TOT recurrence with age.

An established finding with TOT recurrence (e.g., D'Angelo & Humphreys, 2015; Oliver et al., 2019; Warriner & Humphreys, 2008) is that items that elicited TOTs tend to subsequently elicit TOTs at a significantly higher rate compared to items that did not previously elicit a TOT state. The present study had some key differences from past research on TOT state recurrence. First, past research on TOT state recurrence (e.g., D'Angelo & Humphreys, 2015; Warriner & Humphreys, 2008) compared TOT reports to retrieval successes rather than the present approach of comparing TOT reports to non-TOT reports during instances of retrieval failure. Second, no distinctions were made based on whether a TOT state was valid (i.e., a reported TOT aligned with the experiment's target answer) or not, as all TOT states were examined and participants were not presented with the target answer and asked to confirm whether the answer was indeed the word for which they had the TOT state. Third, the current

study used a different set of TOT-inducing stimuli. However, regardless of the comparison conditions and the stimulus set, if TOT states do repeat themselves for the same target word, then the present study should be able to arrive at that pattern even when approaching the issue in a different way and with different stimuli. Specifically, there should be a higher rate of later TOTs for items that previously elicited unresolved TOTs than for items that previously elicited non-TOT reports during retrieval failure. This would provide converging evidence for the findings of Humphreys and colleagues regarding recurring TOT states. To examine this in both young and older adults, the following conditional probabilities were calculated for comparison: the probability of a Phase 4 TOT given that a Phase 3 TOT state was reported (p[Phase 4 TOT State] | Phase 3 TOT State) and the probability of a Phase 4 TOT state given that a Phase 3 non-TOT State was reported (p[Phase 4 TOT state] | Phase 3 non-TOT state).

A 2 (Phase 3 TOT State Condition: Phase 3 TOT and Phase 3 non-TOT) x 2 (Age Group: young adults and older adults) mixed-measures ANOVA was employed to examine effects of prior TOT states and age on the likelihood of re-experiencing a TOT state in Phase 4. Results showed a significant main effect of Phase 3 TOT State Condition on the probability of re-experiencing a TOT state in Phase 4 $F(1, 140) = 82.67$, $MSE = 3.71$, $p < .001$, $\eta_p^2 = .37$. TOT states tended to recur at a significantly higher rate in Phase 4 when a target word elicited an initial unresolved TOT state in Phase 3 ($M = .35$, $SD = .28$) compared to when a non-TOT state was experienced in Phase 3 for the same target word ($M = .13$, $SD = .14$). No significant main effect of Age Group on Phase 4 TOT recurrence was found $F(1, 140) = 0.91$, $MSE = 0.05$, $p = .341$, $\eta_p^2 = .01$. significant interaction between TOT State Condition and Age Group, $F(1, 140) = 0.03$, $MSE = .00$, $p = .872$, $\eta_p^2 = .00$.

Thus, experiencing a prior unresolved TOT state for a general knowledge question led to a significantly higher likelihood of experiencing a later TOT state for that same general knowledge question than when no TOT state occurred during a previous retrieval failure for a general knowledge question. Age did not predict TOT recurrence rates, which is not surprising considering the earlier findings above regarding no differences between older and younger adults on TOT recurrence rates. Also, the effects of a prior TOT state on TOT recurrence did not depend on the age-group membership of the TOT state experiencer.

Resolution Rates

A TOT state resolution occurs when the word that was on the tip of the tongue finally comes to mind. There were three different occasions during which a TOT state resolution could occur: 1) immediately following the indication of the TOT state in Phase 3 when offered a second chance to answer the question, 2) when offered a chance to answer the question in Phase 4 following an initial TOT state in Phase 3, and 3) when offered a chance to answer the question in Phase 5 following an initial TOT state in Phase 3.

Resolution rates fluctuated across phases, with the highest in Phase 3, followed by a decline in Phase 4 and an increase in Phase 5 (see Table 2). This could be due to recurring TOT states, and the increase in resolution rates in Phase 5 could indicate eventual resolution of such states over time.

Table 2. Mean TOT resolution rates across each phase per age group and overall.

	TOT Resolution Rates					
	Phase 3		Phase 4		Phase 5	
	M	*SD*	*M*	*SD*	*M*	*SD*
Overall	.28	.21	.17	.19	.20	.19
Young Adults	.29	.23	.16	.19	.19	.19
Older Adults	.28	.18	.18	.18	.22	.20

To determine whether resolution rates do fluctuate and whether such rates differ by age group, a 3 (Test Phase Resolution: Resolved in Phase 3, Resolved in Phase 4, and Resolved in Phase 5) x 2 (Age Group: young and older adults) mixed-measures ANOVA was employed. Due to a violation of the assumption of sphericity, as indicated by Mauchly's test $\chi^2(2) = 0.57$, $p < .001$, degrees of freedom were estimated via Greenhouse-Geisser correction ($\varepsilon = .70$). Results revealed a significant main effect of Test Phase Resolution $F(1.39, 195.10) = 17.74$, $MSE = 0.66$, $p < .001$, $\eta_p^2 = .11$. Resolution rates for Phase 3 were significantly higher ($M = .28$, $SD = .21$) than those for Phase 4 ($M = .17$, $SD = .19$), $t(140) = 5.08$, $SE = 0.02$, $p < .001$, Cohen's $d = 0.56$. Phase 4 resolution rates ended up being significantly lower than Phase 5 resolution rates ($M = .20$, $SD = .19$), $t(140) = -2.69$, $SE = 0.01$, $p = .024$, Cohen's $d = -0.15$. Also, Phase 3 resolution rates were significantly higher than those from Phase 5, $t(140) = 3.58$, $SE = 0.02$, $p = .001$, Cohen's $d = 0.41$; post-hoc comparisons were made with Bonferroni correction. No main effect for Age Group was found $F(1, 140) = 0.40$, $MSE = 0.03$, $p = .526$, $\eta_p^2 = .00$, nor any interaction effect between Test Phase Resolution and Age Group $F(1.39, 195.10) = 0.50$, $MSE = 0.02$, $p = .542$, $\eta_p^2 = .00$.

Taken together, these results suggest that TOT resolution rates fluctuated for participants after the initial exposure to general knowledge questions. Specifically, participants were able to resolve about one-third of their TOT states within the same phase (Phase 3 resolution rates). This is not surprising, as it may be that, given enough time (a full 16 seconds rather than half that time), participants would have answered those questions correctly. Then in Phase 4, resolution rates were lower but then increased in Phase 5. This pattern could indicate that TOT states that went unresolved in Phase 3 recurred in Phase 4 but were eventually resolved in Phase 5. Also, age had no significant influence over resolution rates, indicating equal eventual target retrieval capabilities between younger and older adults, and that fluctuations in resolutions did not depend on age group membership.

Examining Hypothesis #1: The Effect of Context Change on Resolution Rates

To examine Hypothesis #1—that there would be greater resolution rates following a change in background context from Phase 3 to Phase 4—the probability of TOT state resolution in Phase 4 was compared across the same-context (context reinstatement) and the changed-context situations. The conditional probability for examining this was computed as follows: The probability of a successful retrieval of the answer in Phase 4 given that an unresolved TOT state was reported for it in Phase 3 (p[Phase 4 retrieval] | Phase 3 TOT state) per context condition (context change vs. context reinstatement).

Across both age groups, the conditional probabilities of target retrieval in Phase 4 for initial Phase 3 TOT states appeared to be similar between context change and context reinstatement conditions (see Figure 7). To formally examine these conditional probabilities of target retrieval as a function of context condition and age, a 2 (Context Condition: changed and reinstated) x 2 (Age Group: young and older adults) mixed-measures ANOVA was employed.

Results of the mixed ANOVA suggest that there was no significant main effect of context condition on the conditional probability of retrieval in Phase 4 for unresolved Phase 3 TOT states $F(1, 130) = 0.05$, $MSE = .00$, $p = .828$, $\eta_p^2 = .00$. There was also no significant effect of age group on the resolution rates $F(1, 130) = 0.34$, $MSE = .03$, $p = .561$, $\eta_p^2 = .00$, nor a significant interaction between age and context conditions $F(1, 130) = 0.02$, $MSE = .00$, $p = .893$, $\eta_p^2 = .00$. These results indicate that changing background context did not have a meaningful effect in facilitating resolution for initially unresolved TOT states across the entire sample. Furthermore, no effects of age suggest that younger adults are not more likely to resolve more TOT states compared to older adults. Additionally, no effects of context on later resolution are dependent upon a TOT experiencer's age group membership.

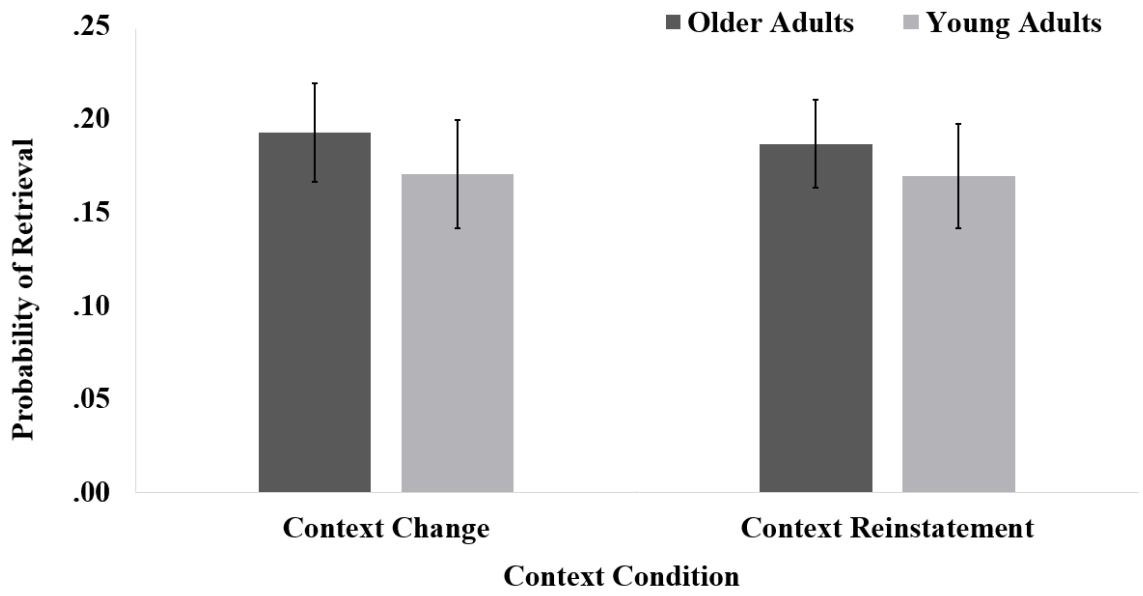

Figure 7. Mean conditional probabilities of Phase 4 resolution of prior unresolved Phase 3 TOT states when context was changed and when it was reinstated for older (dark gray; context change: $M = .19$, $SD = .22$; context reinstatement: $M = .19$, $SD = .20$) and young adults (light gray; context change: $M = .17$, $SD = .23$; context reinstatement: $M = .17$, $SD = .22$). Error bars represent standard errors.

Examining Hypothesis #2: The Effect of Context Change on TOT State Recurrence

Does Self-Resolution Lower TOT State Recurrence?

The second primary hypothesis under investigation concerns the effect of context change on the rate of TOT state recurrence. Before turning to that, it is important to consider that D'Angelo and Humphreys (2015) and Warriner and Humphreys (2008) found that when people could resolve a TOT state on their own, they were less likely to experience a repeated TOT state for that target word in the future, because they were more likely to successfully access the word. To examine whether this pattern occurred in the present study, the probability of a successful target word retrieval in Phase 5 given that a self-resolution occurred in Phase 4 for a Phase 3 TOT state (p[Phase 5 retrieval] | Phase 4 resolution of Phase 3 TOT) was compared to the probability of a target word retrieval in Phase 5 given that a self-

resolution in Phase 4 did not occur (p[Phase 5 retrieval | Phase 4 non-resolution of Phase 3 TOT).

To formally examine later Phase 5 retrieval as a function of whether a prior TOT state was resolved or not as a function of age, a 2 (Phase 4 Resolution: resolved and unresolved) x 2 (Age Group: young and older adults) mixed ANOVA was performed. A significant main effect of Phase 4 Resolution on later Phase 5 retrieval likelihood was found, $F(1, 96) = 430.48$, $MSE = 23.46$, $p < .001$, $\eta_p^2 = .82$, such that resolving a prior TOT state in Phase 4 increased the likelihood of Phase 5 retrieval ($M = .79$ $SD = .32$) compared to when TOT states went unresolved ($M = .10$, $SD = .13$). This replicates and extends prior findings (e.g., D'Angelo & Humphreys, 2015) of self-resolution decreasing TOT recurrence by increasing the likelihood of target retrieval.[1] No significant effect of Age Group was found $F(1, 96) = 0.09$, $MSE = .01$, $p = .76$, $\eta_p^2 = .00$, in addition to no significant interaction between Phase 4 Resolution and Age Group, $F(1, 96) = 0.02$, $MSE = .00$, $p = .904$, $\eta_p^2 = .00$. Thus, eventual resolution of previously unresolved TOT states helps protect the TOT experiencer from subsequent repeated TOT states by increasing the probability of correct target retrieval. This pattern does not vary as a function of age (see Table 3).

1

[1] Although the current study focuses primarily on resolved TOT states, given the research on the testing effect (e.g., Kornell et al., 2015), one might wonder if there are instances wherein past retrievability is not predictive of future retrievability. One example of this can be found in work examining how self-generated retrieval cues lose their effectiveness over time in cueing previously learned information (Mäntylä, 1986; Nilsson et al., 1987). Thus, despite successfully retrieving previously learned information, participants' likelihood of later retrieval for the same information decreased over time. Another example from the work of Benjamin et al. (1998) shows a similar pattern in that previous retrieval does not necessarily lead to later retrieval when such information is accessed quickly, as opposed to a slower manner. It should be noted, however, that unlike these past studies, the current study focused on future retrievability in the context of TOT states and TOT state resolution, focusing specifically on whether eventual resolution increases the likelihood of retrieving the same target in the future and thereby reduces later TOT recurrence.

Table 3. Average conditional probabilities of later retrieval in Phase 5, given that an initially unresolved Phase 3 TOT was resolved (or not) in Phase 4 per age group.

	Conditional Probability of Phase 5 Retrieval			
	Resolved in Phase 4		Unresolved in Phase 4	
	M	*SD*	*M*	*SD*
Overall	.79	.32	.10	.13
Young Adults	.79	.36	.10	.12
Older Adults	.80	.28	.10	.15

Does Changing Context Decrease TOT State Recurrence?

The second main hypothesis under investigation in the present study is the idea that changing context will reduce the likelihood of TOT state recurrence (by increasing target retrieval likelihood). The probability of a successful word retrieval in Phase 5 for the same question, given that the context was changed in Phase 4 for an unresolved TOT state from Phase 3 (p[Phase 5 retrieval] | Phase 4 context change of Phase 3 TOT), was calculated and compared to the probability of target retrieval in Phase 5 given that context was reinstated in Phase 4 for an unresolved TOT state from Phase 3 (p[Phase 5 retrieval] | Phase 4 context reinstatement of Phase 3 TOT).

To examine differences in conditional probabilities of later retrieval as a function of context and age group membership, a 2 (Phase 4 Context Condition: changed and reinstated) x 2 (Age Group: young and older adults) mixed-measures ANOVA was employed. Results indicated no significant main effect of Phase 4 Context Condition on later Phase 5 target retrieval among questions that elicited TOTs in Phase 3, $F(1, 129) = 0.91$, $MSE = .03$, $p = .341$, $\eta_p^2 = .01$. There

was also no significant main effect of Age Group, $F(1, 129) = 1.13$, $MSE = .09$, $p = .29$, $\eta_p^2 = .01$, and no significant interaction between Phase 4 Context Condition and Age Group $F(1, 129) = 0.00$, $MSE = .00$, $p = .994$, $\eta_p^2 = .00$.

Thus, changing context for questions that previously elicited TOT states does not facilitate later retrieval of a target word more so than when context is kept the same. In other words, changing context had no impact on protecting a TOT experiencer from a recurring TOT since it did not lead to an increase in target retrieval, and there were no differences in such later retrieval attributable to age group membership nor any interaction effects (see Figure 8).

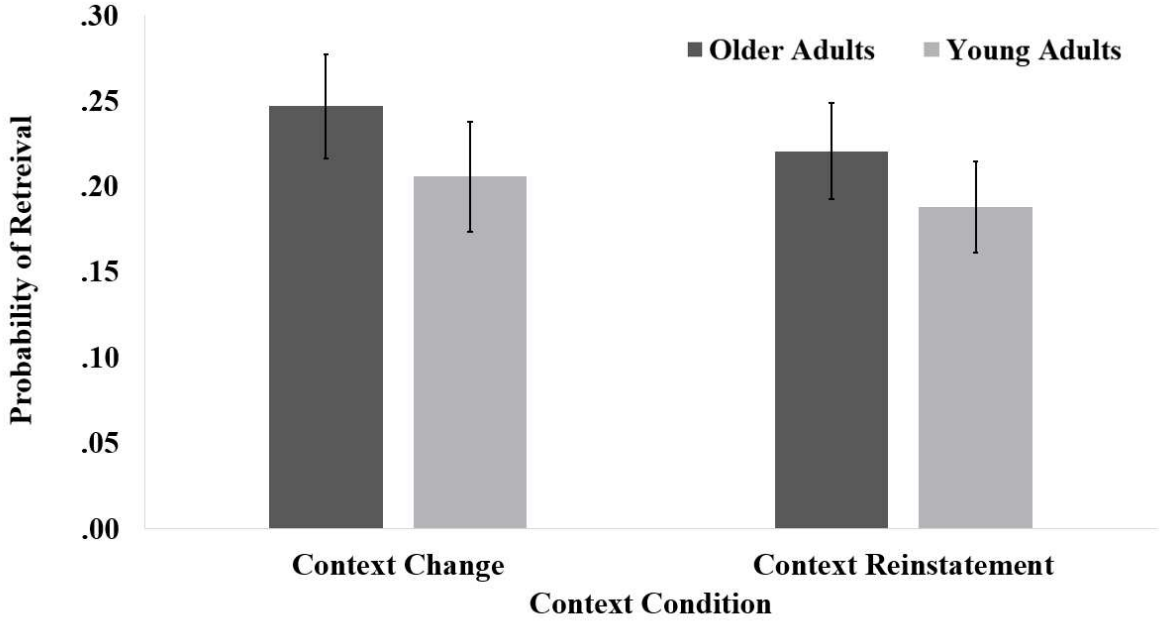

Figure 8. Mean conditional probabilities of Phase 5 retrieval of initial Phase 3 TOT states when context was changed and when it was reinstated for older (dark grey; context change: $M = .25$, $SD = .25$; context reinstatement: $M = .22$, $SD = .24$) and young adults (light gray; context change $M = .21$, $SD = .25$; context reinstatement: $M = .19$, $SD = .21$). Error bars represent standard errors.

TOT recurrence rates in Phase 5 among questions that had elicited TOTs in Phase 3 were also examined as a function of context change and reinstatement in Phase 4 per age group using

a 2 (Context Condition: changed and reinstated) x 2 (Age Group: young and older adults) mixed ANOVA. Based on the results of the mixed ANOVA, changing context did not reduce the likelihood of TOT recurrence, as no significant main effect of Context Condition on TOT recurrence was found $F(1,85) = 0.01$, $MSE = .00$, $p = .921$, $\eta_p^2 = .00$. Additionally, there was no significant effect of Age Group on TOT recurrence either $F(1,85) = 1.68$, $MSE = .00$, $p = .198$, $\eta_p^2 = .02$, nor a significant interaction between Context Condition and Age Group $F(1,85) = 2.28$, $MSE = .15$, $p = .135$, $\eta_p^2 = .03$. The results suggest that changing or reinstating context does not affect later TOT recurrence. Moreover, age had no significant influence on later TOT recurrence either (see Table 4).

Table 4. Average TOT recurrence rates for when context was either changed or reinstated in Phase 4.

	Phase 5 TOT Recurrence Rate			
	Context Change		Context Reinstatement	
	M	*SD*	*M*	*SD*
Overall	.57	.33	.57	.35
Young Adults	.55	.35	.49	.37
Older Adults	.58	.33	.63	.33

Chapter 4 – Discussion

Overview of the Present Study and Results of Primary Hypothesis Tests

The current study sought to examine whether changing one's context could reduce the likelihood that a previously unresolved TOT state would recur. Prior research has shown that TOT states tend to recur over time for the same items such that if a person experiences a TOT state for a target word at one moment, they are highly likely to re-experience a TOT state for that same word at a different time (D'Angelo & Humphreys, 2015; Oliver & Humphreys, 2019; Oliver et al., 2019; Warriner & Humphreys, 2008). Furthermore, resolving a TOT state on one's own (as opposed to having the target word simply presented to the person) reduces later TOT state recurrence for that word; it does so by increasing the likelihood of accessing the word at a later time instead of re-experiencing a TOT state for it (D'Angelo & Humphreys, 2015). Indeed, self-resolving facilitates later access to the target word by helping to create a new route to the word within the language network in a way that merely being presented with the target word does not.

In an entirely different but somewhat analogous realm of research—that of creative problem-solving—researchers have found changing one's context facilitates new routes to accessing an as yet inaccessible piece of information (i.e. that which is needed to solve a novel problem; Beda & Smith, 2018; Smith & Beda, 2020). This served as the basis for the current investigation on whether changing one's context would present a means by which a person experiencing a TOT state could increase the likelihood of resolving that TOT state on their own. Smith and Beda (2020) demonstrated that changing one's context in a problem-solving task reduced the likelihood of retrieving fixated solutions (learned incorrect solutions)

and thus increased the likelihood of generating the correct solution to a problem. Somewhat analogously, activation patterns leading up to an initial TOT state have been posited to be learned through effortful retrieval (see D'Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Although D'Angelo and Humphreys found that presenting a person with an orthographic cue could serve as a means of facilitating self-resolution that, in turn, reduces the likelihood of TOT state recurrence, orthographic cues may be hard to come by in day-to-day life as a viable means of self-resolving a TOT state when it occurs. For this reason, the present study examined the possibility that changing one's context might serve as an alternative means of facilitating self-resolution of a TOT state. Just as changing one's context has been shown to aid in attaining a problem's novel solution by freeing a person from a fixating idea, changing one's context could serve as a method for successful word retrieval that a TOT state experiencer can carry out in daily life (such as by changing their surroundings momentarily), and thus reduce TOT recurrence on their own. Because it is well-documented that older adults experience TOTs with greater frequency than younger adults (see Cleary & Schwartz, 2025, for a review), in the present study, two age groups (young and older adults) were examined to determine whether any potential benefits of changing context would also occur for older adults, who might benefit even more from an effective self-resolution strategy given their higher frequency of experiencing TOTs.

Contrary to the present hypothesis, however, changing context via different background images on the computer screen did not facilitate the eventual resolution of TOT states in either younger or older adults. This finding was demonstrated when comparing Phase 4 resolution rates for prior Phase 3 TOT states as a function of context condition (context change vs. context reinstatement), and also when comparing later Phase 5 retrieval of answers to general knowledge

questions that spawned TOT states during Phase 3 as a function of context condition (changed or reinstated context in Phase 4). In both cases, changing the background context in which general knowledge questions were presented did not increase the likelihood of resolution or later retrieval compared to context reinstatement. From this, the present study demonstrated no support for the idea that a change in one's surroundings could prompt an increased likelihood of retrieval of a sought-after word. Furthermore, the present study found no evidence of a protective benefit of context change in reducing later TOT state recurrence.

Other Theoretically Relevant Findings from the Present Study

While no evidence for the effectiveness of context was found, the current study uncovered several theoretically relevant findings. Though not the main hypothesis under investigation, these three sets of findings from the present study, discussed below, help to inform theoretical understanding of the nature of TOT states and their tendency to recur.

Replicating and Extending Prior Findings from a Novel Angle

First, the present study replicated and extended some key prior findings by Humphreys and colleagues (D'Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). One such finding is that self-resolved TOT states lead to a reduced likelihood that a TOT state for the same word would repeat in the future. In the present study, I used a different computational approach than that used by Humphreys and colleagues in the past. In the present study, resolving a prior TOT state for a target word led to a significantly higher probability of retrieving that target word when cued later by its general knowledge question, compared to when retrieval failure/a lack of resolution occurred earlier for the same word. Another replication and extension of prior work by Humphreys and colleagues was that targets for which TOT states occurred and went unresolved were more likely to later elicit TOTs than targets for which retrieval failure had occurred

without a TOT experience. Note that this was a different comparison than was made by Humphreys and colleagues in that I compared TOT states vs. non-TOT states among instances of retrieval failure, holding retrieval failure constant in our computational approach. In contrast, D'Angelo and Humphreys' (2015) computational approach included retrieval successes when calculating TOT and TOT recurrence rates. Additionally, their criteria for a TOT state differed from the current study. For example, D'Angelo and Humphreys solely focused on reported TOT states that were confirmed to align with their experiment's target answers (i.e., when a TOT state was reported, participants were presented with the correct answer and confirmed whether or not that word was indeed the word for which they were experiencing a TOT state). Such a criterion ignores TOT states that participants may have had for other words besides the target and can be problematic when calculating TOT rates (see Cleary & Schwartz, 2025). Nonetheless, the present study shows converging evidence from a different methodological approach for the findings that 1) TOT states tend to recur, and 2) self-resolution reduces TOT state recurrence by increasing the likelihood of later access to the target word.

Potential Mechanisms of Reduced TOT State Recurrence

Second, in the present study, TOT rates decreased over time across the experiment from Phase 3 to Phase 4 to Phase 5 (with older adults continuously experiencing more TOT states over time compared to younger adults but otherwise showing the same pattern). In line with this, TOT state resolution was more likely during the third test than the second test. Thus, although the present study did not find evidence for a role of changing context in increasing self-resolution, the present study did find evidence for reduced TOT recurrence over time and repeated retrieval attempts, consistent with the recent findings of Xi et al. (2026). Xi et al. found evidence that

when given additional opportunities to attempt to access the target words over the course of an experiment, participants became increasingly likely to access the words over time.

Xi et al. (2026) found that when participants in Experiment 1, which consisted of older adults, had three separate retrieval opportunities to answer TOT-inducing pointers (stimuli that refer to a specific target for retrieval, which included descriptions of vocabulary words and famous actors), they ended up resolving a higher rate of their initial TOT states one-week later compared to a control condition that only had one such opportunity. In their second experiment, Xi et al. found lower TOT recurrence rates when participants were given an extra 30 seconds to engage in retrieval efforts compared to when immediate retrieval was required. While the current study did not have a comparison group whereby fewer retrieval opportunities were allowed for a certain set of general knowledge questions, the present study did have the within-subjects comparison of TOT rates from Phase 3 to Phase 4 to Phase 5 and shows a decline in TOT rates over time with repeated retrieval attempts. Moreover, participants did have two opportunities per test phase to try to retrieve the answer to general knowledge questions, both in relatively immediate succession (initial attempt, TOT indication prompt, and then the partial information prompt, which served as a second attempt), as well as delayed across time such that if questions were not successfully answered during the initial attempt in Phase 3, the question repeated in subsequent test Phases 4 and 5. It appears that something about these various repeated retrieval opportunities ultimately led to the decline in recurring TOT states over time.

Both this pattern in the present study and that reported by Xi et al. (2026) is somewhat similar to past findings of the effectiveness of mentally generated cues in eliciting retrieval insofar as mentally generated cues appear to be tied to the mental context present at the time of initial cue generation, leading the cues to be less effective over time as one's mental context

changes over time (Mäntylä & Nilsson, 1988). Applied to the present pattern of reduced TOTs from Phase 3 to Phase 4 to Phase 5 as well as the recent findings of Xi et al., one could construe that TOTs are at least somewhat tied to one's mental context at the time that the TOT occurs, and that as one's mental context changes over time, the likelihood of TOT resolution increases due to this likelihood of mental context changing.

From this perspective, it is unclear why the manipulation of changing the background context did not work to reduce the likelihood of TOTs. One possibility, discussed below under Limitations, is that a change in background screen image on which the general knowledge question is overlaid is not a powerful enough change in context to elicit increases in self-resolutions. A fully immersive change in surroundings might be a more powerful manipulation. Another possibility also discussed under Limitations is that there is overshadowing by the fact that the general knowledge question is itself a powerful contextual cue that is continuously reinstated in each phase, and that form of context reinstatement overshadows any effect of changing the background image onto which the question is overlaid. In any case, it is worth continuing to consider whether mental context change might be at least partially responsible for the increase in TOT resolutions over time with continued attempts.

Are Increased TOTs with Age Due to a More Expansive Knowledge-base?

A third theoretically relevant finding from the present study was that although older adults experienced a higher rate of TOTs compared to younger adults, as predicted based on prior research (e.g., Cleary & Schwartz, 2025), older adults also answered more general knowledge questions overall than younger adults. This finding is consistent with the perspective of Gollan and Brown (2006), who argued that TOT states should be viewed as indicators of retrieval success rather than failure, in that they indicate access to *something* in memory as

opposed to nothing at all. To the extent that correctly answering more questions indicates having a greater knowledge-base of questions and their answers in the first place, the simultaneous finding that older adults experience greater TOT rates than younger adults may be a reflection of that greater knowledge-base. In this way, rather than indicating a greater propensity for retrieval failures with age, the greater TOT rates seen in older than younger adults may be a reflection of the greater knowledge-base of older adults and the greater opportunities for TOT states that that presents.

Gollan and Brown (2006) note that older adults have a greater number of TOTs and higher retrieval rates for difficult targets compared to young adults; however, no such retrieval advantage was found for easy target words. Gollan and Brown also found similar discrepancies in TOT rates observed between monolinguals and bilinguals such that monolinguals experienced more TOT states with difficult words than bilinguals. These findings suggest that both monolinguals and older adults experienced more TOT states for difficult words due to having sufficient knowledge about the difficult targets to create opportunities to experience TOT states for them. Consistent with this idea, research points to higher TOT rates being primarily attributable to greater accumulated vocabulary knowledge when effects of age are controlled for (e.g., Dahlgren, 1998). While some research has demonstrated the opposite effect of accumulated vocabulary knowledge in older adults (e.g., Shafto et al., 2017), it may be that the benefits of an expansive knowledge base with regard to TOT states are apparent only for difficult words, as demonstrated by Gollan and Brown (2006).

Although the current study did not find any evidence for older adults experiencing greater resolution for their TOTs relative to young adults, older adults did not experience more recurring TOT states than young adults either, as those rates were similar among the two groups, and later

retrieval rates of resolved TOTs for the same target word were roughly equal as well. Additionally, despite no evidence for a resolution advantage in older adults in the current study, and conflicting results on vocabulary knowledge-base effects on TOT states (e.g., Burke, et al., 1991; Dahlgren, 1998; Shafto et al., 2017), it may be that advancing age comes with both advantages and disadvantages such as increased access to difficult words coupled with deterioration of semantic networks, leading to greater TOT rates for easy words (Gollan & Brown, 2006; Schwartz & Frazier, 2005).

Limitations of the Present Methodology

Background Images May not Be Powerful Contexts to Change

As previously mentioned, using still background images on the computer screen as a form of context may not be an efficient way to establish context in the first place. This may reflect the lack of immersivity and the subjective feeling that one is present in a specific context. The use of Virtual Reality (VR) in a future study could allow for a more impactful and dramatic effect when changing or reinstating context due to greater immersivity. As an example of the effects of increased immersion, prior research on déjà vu using a VR system with a head-mounted display (HMD) demonstrated enhancement to various facets of episodic memory due to an increase in VR scenes' immersivity compared to prior scenes displayed strictly on a computer monitor (Okada et al., 2023). Other research has shown similar effects of VR on episodic memory performance as well (for a brief review see Smith, 2019).

An important aspect with regard to immersion in a virtual context is the feeling of presence in such a context, which can be considered a sort of mental transportation to a virtual environment that is not strictly dependent on immersivity (the fidelity to which a virtual environment has to the real environment it is representing), but can be affected by it (Nash et al.,

2000; Slater, 2003; Smith & Mulligan, 2021). Despite the richness of content within the background images in the current study, perhaps there was a lack of presence experienced by participants, and so switching contexts lacked sufficient power to disrupt learned TOT activation patterns.

Possible Overshadowing and Outshining of Context Effects

Another possible explanation for the lack of context effects in the present study is that the general knowledge questions themselves served as stronger cues for the specific learned activation patterns that are purported to underlie recurring TOT states. This could occur in one of two ways: overshadowing during learning and outshining during retrieval at test (Smith & Vela, 2001).

Similar to how overshadowing effects can occur during associative learning when a more salient cue is associated with a given event than a less salient cue (e.g., Matzel et al., 1985), it may be that general knowledge questions were better associated with retrieved memory representations, due to the background image context not being salient enough (i.e., presentation of a still context on a computer screen), and thus contextual information was not properly encoded or paired with generated memory representations and activation patterns, which led to the reduction or absence of contextual cueing effects (Smith & Vela, 2001).

On the other hand, semantic or interitem association (target item-related information) could have led to outshining of context effects, provided that such associations were present during initial learning, which can be generated internally by the person and need not be provided by an external source (Smith, 1994; Smith & Vela, 2001), which is the case with TOT states, as people can end up retrieving or generating partial target information, which includes but is not limited to a target word's orthography, phonology or semanticity (e.g., Burke et al., 1991).

Outshining has been documented in work examining the effects of context during recognition tests, with item probes serving as sufficient cues for facilitating retrieval of stored memory representations to the extent that reliance on context was unnecessary for recognition, as target-related information felt strongly familiar and thus the decision for considering an item as old was based on that familiarity, and thus contextual information was not leveraged during recognition (Zaborowska et al., 2024). A similar outshining effect occurred during Beda and Smith's (2018) Experiment 1 on context and learning fixation (learned incorrect solutions), wherein paired semantic associations between Remote Associate Task (RAT) problem components and incorrect solutions (e.g., Cottage – *hut*) were so strong that contextual effects were obscured.

In regard to the current study, perhaps the context was not encoded properly, such that during the initial context-encoding phase (Phase 1), attention was purely or mostly allocated to the statement versions of the general knowledge questions, as well as during the copying phase (Phase 2), when participants were tasked with copying a given statement. As for Phase 3 (the first test phase), the background context was not salient enough in comparison to the general knowledge question, and thus not encoded, which led to the question itself serving as the primary cue for learned TOT states in subsequent tests. Additionally, internally generated information was probably sufficient, after being associated with a given question, to trigger other target-related information, and thus, context was not used to assist in generating additional information.

Another potential explanation for the lack of contextual cueing effects may be due to cue overload (Watkins & Watkins, 1975). According to the Cue Overload Principle, the effectiveness of retrieval cues in facilitating successful recall is adversely impacted when a greater number of items or information is associated with such cues. In other words, retrieval cues can be

oversaturated with associated information to the extent that they no longer assist with the retrieval of learned information. Due to the volume of unique background contexts required for the 80 general knowledge questions, and the addition of novel contexts during the context change conditions, various backgrounds shared common elements (e.g., outdoor contexts shared greenery, trees, dirt, etc.), to the point that cue overload may have been present. Perhaps context was encoded by participants, but due to common elements present in multiple contexts, the effectiveness of context in reinstating prior memory representations and activation patterns was diminished. However, cue overload may not be the main driving factor for the lack of context effects, as cue overload was not present in the similar paradigm carried out by Smith and Beda (2020).

The Timing of the Context Change

Another possible limitation of the present methodology concerns the timing of the changed background context. The background context change did not happen immediately following the onset of the TOT state. Instead, it happened in a subsequent phase or block, going from Phase 3 to Phase 4. It is possible that any context effects on TOT state resolution not only require a more dramatic change of context, as discussed above, but also immediacy with regard to when the initial TOT state occurred. That is, it may be more ideal to change context immediately following a TOT state report, particularly if that changed context is dramatic enough (due to sufficient immersion and presence) to induce a mental context change as described above (e.g., Mäntylä & Nilsson, 1988; Xi et al., 2026).

Future Directions

Although the present study failed to find any effects of background image context on TOT recurrence or resolution likelihood, the growing body of evidence on the benefits of

repeated retrieval opportunities over time (coming from the present study and the recent findings of Xi et al., 2026), coupled with past work in other domains on the role of context change in mental access to information (e.g., Beda & Smith, 2018; Mäyntaylä & Nilsson, 1988; Smith & Beda, 2020) make the question of context a worthwhile pursuit for future research on TOT states. There are several important directions that future research on the role of context in reducing TOT state recurrence could take. These are discussed in turn below.

More Immersive Contexts

In order to address the lack of immersion and presence of still background images as a form of context, the current design could be changed to capitalize on the enhancing effects of VR (e.g., Okada et al., 2023). Such effects of greater immersion have been demonstrated in work examining context-dependent memory such that context reinstatement led to better memory outcomes more so than a change in context (Shin et al., 2021).

Instead of using still background images on a computer screen, the approach taken in the present study could be modified by using similar scenes to those of Okada et al. (2023). An HMD VR system would allow participants to be fully surrounded by their virtual environment, which should increase their feeling of presence within that environment, as opposed to feeling present in a laboratory computer booth. This increase in presence within virtual environments would then allow any shifts of context to be more dramatic or salient to the TOT experiencer, and thus momentarily draw attention away from ongoing internal representations and allow room for novel ones, and thus lead to successful target retrieval.

More Immediate and Dramatic Context Changes

In addition to the employment of VR, a future experiment could change context immediately following a TOT report, so that attention may be momentarily pulled

externally to disrupt a TOT experiencer's current set of mental representations. Similarly, another way to dramatically change one's context could be to transition participants from VR into another room (e.g., from the room housing the VR system to a different room). Of course, such a change would be more akin to location updating, as a person will transfer from one set of surroundings into another via a doorway (e.g., Radvansky & Copeland, 2006). Indeed, perhaps such a method would be drastic enough to create a viable path towards TOT resolution, as large effect sizes tend to be found in the location updating literature (Radvansky & Zacks, 2017). It would also be more in line with practical reality since a TOT experiencer can make a shift in context by walking into a different room and updating their ongoing set of mental representations (i.e., make TOT-related representations less accessible by relocating into a new room). One issue with this could be that there would not be enough unique rooms to transfer into following each TOT state that arises; however, transferring into another room could still be an option within VR with two distinct virtual environments adjacent to one another and separated by a doorway.

Changing the Pointer Type

Despite addressing the aforementioned issues, it may be that outshining or overshadowing effects could persist within VR, as the written general knowledge questions themselves may still serve as stronger cues for reinstating recurring TOT states, and so any effects of contextual cueing would continue to be minimal or diminished. One way to address this in the future could be through the auditory presentation of the general knowledge questions. This would allow uninterrupted visual perception and encoding of a virtual environment since there is no written question to immediately capture participants' attention.

Induction of Mental Context Change

As Humphreys and colleagues posit, certain pathways or activation patterns can be learned for target words that spawn unresolved TOT states (D'Angelo & Humphreys, 2015; Warriner & Humphreys, 2008). Such activation patterns or mental activity may be so well ingrained by a TOT experiencer that a simple shift in environmental context may still not be sufficient to clear a path towards resolution or to reinstate a prior TOT, as general knowledge questions even in auditory form may still overshadow or outshine contextual information. Perhaps targeting mental context more directly or providing additional cues to promote a shift in mental context would be more effective.

Mental context, which is separate from physical context, comprises internal contextual elements such as mood, physiological states, or accompanying thoughts that surround a particular experience (Eich, 1980; Kenealy, 1997; Mulji & Bodner, 2010; Sahakyan & Kelley, 2002). The internal information accessible to a TOT experiencer, such as target-related representations, familiarity, and the quantity of information retrieved, could be considered the mental context for a particular TOT state. Thus, shifting one's mental context following an initial TOT state could be beneficial in facilitating resolution and subsequently reducing the likelihood of TOT recurrence.

The notion of forgetting irrelevant information such as fixated solutions (e.g., Smith & Beda, 2020) is similar to what is accomplished in the directed-forgetting literature. In such work, participants are tasked with learning two lists of words and are either given an instruction to forget a prior list (just before recall) or not. Instructing participants to forget prior learned information enables them to better remember the contents of the second learned list, while also adversely impacting memory for the initially learned list (Basden et al., 1993; Bjork et

al., 1973; Sahakyan & Kelley, 2002). One explanation for directed-forgetting proposes that when participants are told to forget prior learned information, they refresh their mental context by changing the representations they retrieve or think about, such as thinking of anything other than the prior learned information (Mulji & Bodner, 2010; Sahakyan, 2004; Sahakyan & Kelley, 2002). Some paradigms in shifting mental context have demonstrated that explicit instruction to forget may not even be necessary to promote a change in mental context, and that change or reinstatement of mental contexts show similar effects on memory elicited by the change and reinstatement of physical context (e.g., Sahakyan & Kelley, 2002).

Another potential method for shifting a TOT experiencer's mental context could be by associating TOT-related representations with certain moods or emotions as the TOT state unfolds, given past studies on the effects of reinstating mood context on memory (Teasdale & Russell, 1983; Ucros, 1989); however, some work on mood-dependent memory has not found reliable supportive evidence for the effects of mood change or reinstatement on memory (Kenealy, 1997), so it is unclear if mood will present a powerful enough mental context change to affect TOT state likelihood.

Future studies on context and recurring TOT states could capitalize on targeting mental context directly by requiring participants to engage in a task that guides participants to retrieve representations that are unrelated to the target word that initially evoked a TOT state, so that mental context can shift away momentarily and increase the likelihood of resolution.

Conclusions

Despite the lack of evidence obtained in the current study for the effects of context change and reinstatement on TOT resolution and recurrence, prior findings by Humphreys and

colleagues (D'Angelo & Humphreys, 2015; Oliver & Humphreys, 2019; Oliver et al., 2019; Warriner & Humphreys, 2008) were replicated such that participants had a reduced likelihood of TOT states repeating after resolving them. In extension of these prior findings, the current study found that TOT state resolution increases the likelihood of later target word retrieval, and so the likelihood of a TOT state repeating for the same word in the future decreases once it has been resolved. Additionally, similar to findings by Xi et al. (2026), TOT recurrence rates decreased over time, which may suggest that having multiple opportunities to engage in retrieval efforts distributed over time is effective for reducing repeating TOT states. Taken together, it seems that continued persistence with retrieval efforts to resolve a TOT state may be the most beneficial strategy a TOT experiencer can make. However, it is up to the TOT experiencer to choose what strategy to employ, which may differ across age groups, as some research suggests older adults may opt to rely on spontaneous resolution compared to younger adults who may continue with their retrieval efforts in their attempt to resolve a TOT state (Burke et al., 1991). If differences in strategy employment played a role in the likelihood of a TOT state repeating, then I would have observed discrepancies in TOT recurrence rates between young and older adults; however, I found no such differences in recurrence rates, nor did I find differences in resolution rates.

While no evidence for contextual cueing and increased target retrieval was found, various new methodological approaches could be explored in future research, such as the nature and timing of the specific context a TOT experiencer is immersed in, the type of TOT-inducing pointer used to elicit TOT states which may overshadow or outshine contextual information, and the inclusion of methods that either support the cueing effects of external contextual

information or that target mental context directly to allow for greater likelihood of target retrieval.

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Appendix A

Demographics Questionnaire

1. Please indicate your age _____

2. Please indicate your gender identity (select one)

   female male non binary/third gender prefer not to say

   prefer to self-identify _____

3. Please indicate your educational level (number of years) _____
   (number of years; e.g. 12 if you're in your first year of college)

4. To what ethnic group do you belong? Please select (optional)
   _____ Caucasian/White (non-Hispanic): Persons with origins in any of the original peoples of Europe, North Africa, or the Middle East.

   _____ Black (non-Hispanic): Persons with origins in any of the black racial groups of Africa.

   _____ Asian or Pacific Islander: Persons with origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands.

   _____ Native American or Alaskan Native: Persons with origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.

   _____ Hispanic: Persons of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.

   _____ Prefer not to say

   _____ Other (please clarify):

5. Are you a native English speaker? _____ YES _____ NO

   --If NO, approximately how many years have you spoken English? ____ years