"Blockers" do not block recall during tip-of-the-tongue states

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Abstract Tip-of-the-Tongue experiences (TOTs) are often accompanied by incorrect answers (blockers) that come to mind persistently and seem to block recall. According to the blocking hypothesis, blockers cause retrieval difficulty during TOTs. We predicted that delay would allow participants to forget their blockers, and thereby enhance TOT resolution. In Experiment 1 participants were asked trivia questions and then retested on the ones that elicited TOTs, either immediately or after a delay. There was an incubation effect overall, with greater TOT resolution after a delay than on an immediate test. Contrary to the blocking hypothesis, however, delay did not enhance resolution of blocked TOTs more than non-blocked TOTs. In Experiment 2, during the retest, participants were reminded of their previous blockers on some questions, but the reminders did not affect TOT resolution. These findings suggest that blockers may be a side effect, not a cause, of retrieval difficulty during TOTs.

Keywords Tip-of-the-Tongue · Blocker · Memory · Metacognition · Incubation

The tip-of-the-tongue state (TOT) is a fairly common and often frustrating state in which one feels one can almost, but not quite, recall an elusive word or name. TOT states are often accompanied by correct fragmentary information about the desired word, such as its first letter and number of syllables (e.g., Brown, 1991; Caramazza & Miozzo, 1997; Koriat & Lieblich, 1974; Miozzo & Caramazza, 1997). A TOT is a metacognitive state, in the sense that it involves a high feeling of knowing coupled with a feeling that recall is imminent (Schwartz, 2001, 2002a, b; Schwartz, Travis, Castro, & Smith, 2000). TOTs are also quite

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common, occurring about once a week (Brown, 1991), and more often for older people (e.g., Brown & Nix, 1996; Burke, MacKay, Worthley, & Wade, 1991; Maylor, 1990b; White & Abrams, 2002). TOTs generally occur for answers that exist in memory and are only temporarily inaccessible, and in fact most TOTs are solved eventually (e.g., Burke et al., 1991; Reason & Lucas, 1984). Some TOTs are accompanied by what we will call a *blocker*, that is, an answer one knows to be incorrect, but which persistently comes to mind during a TOT. Blockers have been called many names, including blocks (Schacter, 1999), persistent alternates (Burke et al., 1991), related words (Brown, 1991), interlopers (Jones & Langford, 1987), and ugly sisters (Reason & Lucas, 1984). Approximately half of all TOTs are accompanied by blockers (Burke et al., 1991; Heine, Ober, & Shenaut, 1999; Reason & Lucas, 1984). In this article we investigate whether blockers do indeed block retrieval during TOTs.

The core goal of education is to allow students to learn information so that they can recall it later. A TOT is a recall failure. What's more, it is a failure to recall information that one has already learned. Avoiding such memory failures, especially for information one knows, should be a central goal of education. Thus the role (or lack thereof) of memory blocks is important not just for theoretical reasons (as descried below), but for practical ones as well. If blocks cause retrieval failures, they should be avoided (for example, by insuring that interfering information is not allowed to block memory retrieval). If blocks do not cause retrieval failures, such efforts are not necessary. An analogy can be drawn to a related memory phenomenon, retrieval-induced forgetting, which occurs when the retrieval of some information from memory causes forgetting of related information that was not retrieved. Retrieval-induced forgetting has educational implications; for example, taking a practice test has the potential to make students less likely to remember information not included on the practice test than they would have been had they not taken the practice test at all (Macrae & MacLeod, 1999). Other evidence suggests, however, that retrieving information from memory on a test might facilitate memory for related information, instead of suppressing it (Chan, McDermott, & Roediger, 2006). In both retrieval induced forgetting and TOTs, there are practical implications of the role of related information in suppressing-or supporting-memory.

Theoretical explanations of TOTs

According to the *blocking hypothesis* (Jones, 1989), blockers prevent the retrieval of correct answers during TOTs. In doing so, they make TOTs occur, and they make resolution (i.e., thinking of the answer) difficult. The blocking hypothesis has been endorsed by researchers investigating experimentally induced blockers (e.g., Jones, 1989; Smith, 1994) and naturally occurring blockers (e.g., Reason & Lucas, 1984; Woodworth, 1938). In a variant of the blocking hypothesis, Burke et al. (1991) hypothesized that naturally occurring memory blockers do not cause TOTs, because as people age blockers decrease in frequency but TOTs increase, but they do make TOT resolution more difficult.

Theories of TOTs have to explain two related, but potentially different, phenomena—the causes of TOTs, and the reason TOTs are difficult to resolve when they occur. These are not necessarily the same; for example, if a question is very difficult, decreasing its difficulty (by giving a hint, for example) might actually make a TOT more likely to occur, not less—that is, TOTs can occur because an answer comes closer to being recallable. The current research only directly addresses the resolution of TOTs (i.e., the rate at which answers are successfully retrieved), not the causes of TOTs.

There are three dominant theories of TOTs: blocking, partial activation, and metacognitive control. In partial activation theory, TOTs result from errors in speech production (e.g., Burke et al., 1991; James & Burke, 2000). Incomplete activation of a target word during TOTs is hypothesized to be caused by a transmission deficit, that is, a disconnect between priming that normally activates a phonological representation and its actual activation. This theory explains a number of findings, including why TOTs tend to occur for infrequently used words, the fact that TOTs increase as people age, and the fact that presenting phonologically related words can help TOTs to be resolved (James & Burke, 2000). In metacognitive control theory (e.g., Schwartz, 1999, 2001, 2002a), a TOT is a phenomenological experience that is caused primarily by factors that affect metamemory judgments, such as the familiarity of a cue and the fluency with which related information comes to mind. In this theory, the state of memory plays a secondary role to memory monitoring, although obviously it is crucial that the correct answer be unavailable in memory, at least temporarily. The finding that people report "illusory" TOTs on question that have no correct answer supports this theory (Schwartz, 1998).

Insight and incubation

The concept of a memory blocker is similar to the gestalt concept of functional fixedness in problem solving. According to this view, correct solutions are blocked by incorrect solutions, and insight occurs when the block is overcome (Mayer, 1995). Classic experiments such as the candle and matchbox problem (Adamson, 1952; Duncker, 1945), and *Einstellung* problems such as the water-jar problem (Luchins, 1942) are purported to demonstrate blocking in problem solving. The solution to such problems sometimes comes in a flash of insight (Metcalfe, 1986a, b; Metcalfe & Wiebe, 1987). The same experience seems to happen in TOTs, when an answer suddenly "pops-up" into consciousness unexpectedly (Burke et al., 1991; Reason & Lucas, 1984; Schwartz, 2002a; but see Read & Bruce, 1982). There are major differences between TOTs, which involve a temporary failure to recall a word or answer, and problem solving, which often involves a creative solution to problems that one has not previously encountered. Even so, in both problem solving and TOTs, people are thought to experience sudden insights by overcoming mental blocks (Smith, 1994).

Another aspect that TOTs and problem solving have in common is that they are thought to benefit from *incubation effects*—that is, that putting off thinking about a question increases the likelihood that one will think of the answer. In general, replicable experimental evidence for incubation effects in problem solving is scarce, although it has been studied extensively (see, e.g., Kaplan & Simon, 1990; Smith & Blankenship, 1989, 1991). For example, Smith and Blankenship (1989) presented misleading hints (blocks) during problem solving. Participants were better at solving the problems after a delay than immediately, presumably because they forgot the misleading hints and thus were no longer misled after the delay. Many authors have suggested that analogous incubation effects should be obtained in blocked TOTs, because after a delay the blocker will be forgotten (Burke et al., 1991; Jones, 1989; Reason & Lucas, 1984; Schacter, 1999; Smith, 1994; Woodworth, 1938). Choi and Smith (2005) obtained such an incubation effect; they showed that participants were more likely to resolve TOTs when they returned to them after a delay than immediately. They hypothesized that the delay allowed the blockers to be forgotten. The current experiments are the first direct test of that hypothesis.

Natural and experimentally presented blockers

Research on TOTs has employed two types of blockers: naturally occurring blockers—which were used in the current research—and experimentally presented blockers. Naturally occurring blockers have the advantage of being externally valid. Experimentally presented blockers are useful because they allow experimental control, but there is reason to believe their effects on TOTs are not the same as naturally occurring blockers (Jones & Langford, 1987; Schwartz, 1999). Unlike naturally occurring blockers, which are particular to the person who generates them, experimentally presented blockers may actually serve as hints in some cases, either by leading to successful retrieval of the answer, or by causing TOTs on questions that would otherwise be answered "I don't know" (e.g., Brown & McNeill, 1966; James & Burke, 2000; Meyer & Bock, 1992; Perfect & Hanley, 1992, White & Abrams, 2002).

A large proportion of naturally occurring blockers are phonologically related to the target word (e.g., Burke et al., 1991). Blocked TOTs tend to take longer to resolve than TOTs without a blocker, which supports the hypothesis that blockers cause retrieval difficulty during TOTs (Burke et al., 1991; Reason & Lucas, 1984). These studies were correlational, however, and the fact that blockers are correlated with retrieval difficulty does not prove that they *cause* retrieval difficulty. One could imagine quite the opposite, for example: During a TOT, heightened difficulty during memory search might cause a void in conscious awareness, making room for a "blocker" to fill the gap.

In perhaps the best-known study of experimentally presented blockers, Jones and Langford (1987) showed participants definitions of rare words and asked them to recall the words. On some trials, the definition was accompanied by a word that was related to the correct answer either semantically or phonologically, which was meant to serve as a blocker; on other trials, the accompanying word was unrelated to the correct answer. TOT rates were higher when the phonologically related blocker was presented. This finding has been replicated using the same set of questions (Jones, 1989; Maylor, 1990a). Further research revealed, however, that the question set that had originally been accompanied by "blockers" elicited the most TOTs even when no blockers were presented (Perfect & Hanley, 1992). Further, when equally difficult questions were used in each condition, the apparent inhibitory effect of blockers disappeared (Meyer & Bock, 1992; Perfect & Hanley, 1992).

Thus, experimentally presented blockers do not necessarily have the same effects on memory as naturally occurring blockers, and in any case produce mixed results. Naturally occurring blockers do seem to be associated with retrieval difficulty during TOTs, but there is no evidence for the hypothesis that they *cause* retrieval difficulty during TOTs. Despite these findings, the blocking hypothesis lives on; discussing the role of experimentally presented blockers in causing TOTs, James and Burke (2000) summarized the situation thus: "Despite the absence of supporting evidence and the availability of counterevidence, the blocking explanation of TOTs has a tenacious hold and is widely cited." (p. 1381).

Experiment 1

In Experiment 1, participants were presented with general information questions and asked to report occurrences of TOTs. When a TOT occurred, they were asked whether it was accompanied by a blocker. The questions were retested either immediately or after a delay.

Based on the blocking hypothesis, we predicted that in the presence of a blocker, delay would allow the blocker to fade, and thereby improve recall. We predicted that in

comparison, non-blocked TOTs would benefit less from delay. Partial activation theory predicted that, whether people experience a blocker or not, TOT resolution should improve with a delay—if the delay period involves exposure to verbal materials—because sounds may be encountered that, because they were not activated, caused the TOT to occur (Choi & Smith, 2005, interpret partial activation theory differently, however). Metacognitive monitoring theory does not make strong predictions with respect to delay, but it has been argued that if delay decreases the phenomenological experience of a TOT, it will decrease motivation to remember, and thus it might have little positive effect on resolution, and might even be harmful (Choi & Smith, 2005).

Materials and methods

Participants Sixty-four Columbia University students, ages 18–30, participated for credit in introductory psychology courses.

Design The experiment was a 2×2 within-participants design. The factors were test delay (immediate or delayed) and TOT type (blocked or non-blocked). The former was experimentally manipulated; the latter was a quasi-experimental variable that was controlled by the participant.

Apparatus and materials The experiment was run on Macintosh computers. The materials were 213 general information questions, which were taken from Nelson and Narens (1980).

In a pilot experiment which used the same question set as Experiment 1, Columbia University students were asked to report (a) the occurrence of a TOT, (b) the occurrence of a blocker, and (c) what the blocking word was. Blockers accompanied 48% of TOTs; 88% of blockers were semantically related to the answer and 17% were phonologically related.

Procedure The instructions stated that being in a TOT means "You feel as if you definitely know the answer to the question, and you feel as if you will get it at any second. Tip-of-the-tongue is often a tantalizing, frustrating feeling." The description of a blocked TOT was: "The wrong answer keeps coming to mind over and over, and the thing is you know it's wrong, but it won't go away and you feel like it is blocking you from getting the right answer." Unblocked TOTs were called "True" TOTs, and were described thus: "You feel as though you are on the right track, and the answer is on the tip of your tongue, but it just won't come. No wrong answer in particular is coming to mind." We did not want participants to feel that they had to report at least a few TOTs if they did not have any, so in order to minimize demand characteristics (see Widner, Smith, & Graziano, 1996), participants were informed that some people do not have many TOTs, and that the questions were very difficult.

The experiment lasted 40 min. Each trial began with a question, which was on the screen for a maximum of 8 s. If the participant knew the answer to the question, they pressed a button on the screen labeled "Got It," typed the answer in, and went on to the next trial. Otherwise, after 8 s, the participant was given a choice between three buttons, labeled "TOT," "close but no TOT," and "I can't remember." The middle button was included so that participants would not press TOT when they experienced a high feeling of knowing but not a TOT. If the participant chose "TOT," two more buttons appeared, one labeled "True" and one labeled "Blocked," and the participant indicated which type of TOT they were experiencing. What happened next depended on whether the particular trial was randomly assigned to the immediate or delayed condition.

On immediate trials, the question immediately reappeared on the screen and the participant was given 25 more seconds to answer it. On delayed trials, the next question was presented, and the experiment continued. Participants were not told that the delayed questions would be repeated at the end of the experiment.

At the ostensible end of the experiment, participants did a five-min non-verbal distractor task in which they were asked to indicate which of two squares contained more dots. No participant reported having thought about the trivia questions during the distractor task. Following the distractor task, questions that had elicited a TOT and were assigned to the delayed test condition were re-presented in random order, and (like the immediate condition) the participant was given 25 more seconds to try to think of an answer to each question.

Results and discussion

In all of the analyses reported herein, an alpha level of $p<.05$ was used to determine significance. Partial eta squared was used as the measure of effect size, which will be designated ES. To be included in the analyses, a participant needed to have at least one observation in each of the four conditions, which required that a participant report at least two blocked and two non-blocked TOTs. Fifty-six of the 64 participants satisfied this requirement and were included in the analyses.

TOTs occurred on 9% of the trials, and of those 35% were blocked. The rate of TOT resolution was defined as the proportion of TOT questions that were answered correctly—that is, the number of correct answers on the retest divided by the total number of TOTs in that condition. As Fig. 1 shows, TOTs were more likely to be resolved in the delayed than immediate condition, $F(1,55)=4.38$, $MSE=0.083$, $ES=0.074$. Blocked TOTs were resolved less frequently than non-blocked TOTs, $F(1,55)=9.19$, $MSE=0.072$, $ES=0.143$, replicating previous findings (e.g., Burke et al., 1991). However, the prediction of the blocking hypothesis, that delay would especially benefit blocked TOTs, was not supported; the TOT

Fig. 1 Proportion correct on the retest for questions on which participants reported TOTs (i.e., proportion resolved) in Experiment 1. Scores are reported as a function of whether or not participants reported experiencing a blocker, and whether the retest was immediate or delayed. *Error bars* represent standard errors
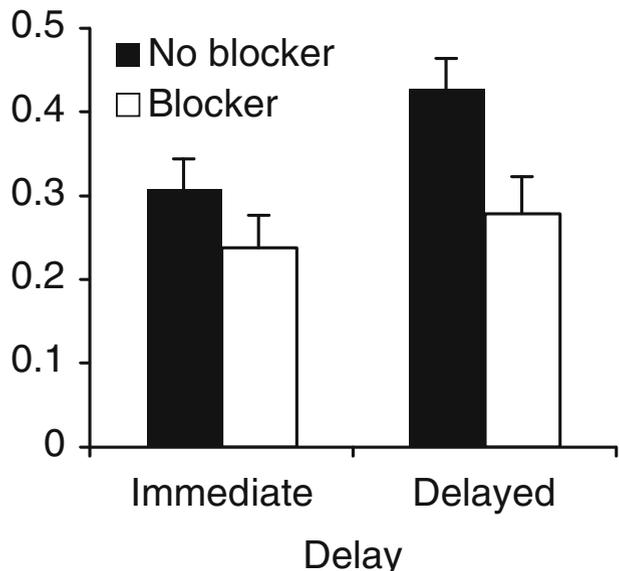
type x delay interaction was not significant, $F(1,55)=1.23$, $MSE=0.068$, $ES=0.027$. This effect was not close to significant; in fact, blocked TOTs were numerically *less* affected by delay than non-blocked TOTs, the opposite of the prediction of the blocking hypothesis.

One potential explanation for why blocked TOTs were resolved less frequently than non-blocked TOTs is that blocked TOTs occurred on more difficult questions. This does not appear to be the case: Blocked and non-blocked questions did not differ significantly in difficulty, $t(55)=-1.19$, as measured by the Nelson and Narens (1980) norms.

Experiment 2

In Experiment 1 there was an incubation effect—overall, delay increased TOT resolution. Delay did not increase TOT resolution any more on blocked TOTs than when no blocker was present, however, providing evidence that blockers do not cause retrieval difficulty during TOTs. That conclusion, however, is predicated on the assumption that the delay actually caused participants to forget their blockers in Experiment 1. Experiment 2 tested that assumption. It also tested the effect of reminding people of forgotten blockers, which—according to the blocking hypothesis—should re-block memory retrieval, and thus decrease rates of TOT resolution. In contrast, if blockers do not cause retrieval difficulty during TOTs, reintroducing forgotten blockers should not affect TOT resolution rates.

In Experiment 2, participants were asked trivia questions, and asked to report TOTs and blockers. The immediate condition was eliminated; after a delay, participants were retested on the questions that had elicited TOTs. During the retest—the crucial test of the hypothesis—on some trials participants were shown the word that they had previously reported was blocking them on that question (Reminder condition). The blocking hypothesis predicted that reintroducing a blocker should hinder retrieval (assuming the blocker was forgotten during the delay, which this experiment also tested). The reminder condition was compared to a condition in which instead of their blocker, participants were shown an unrelated word (Unrelated condition). On non-blocked TOTs in the reminder condition, participants were shown a word related to the correct answer.

At the end of the retest, participants were asked to free-recall as many of their blockers as they could. The free recall test was used as a proxy for the cued retest that immediately preceded it. It is the cued recall test, when the blocker would have its blocking effect, which is of interest in both Experiment 1 and 2. The free recall test was used instead based on the following reasoning: If a blocker continued to block during the retest, it should be relatively easy to remember on the free recall test that followed, because blockers are annoyingly prominent in consciousness during TOTs. Thus a blocker that was not recalled on the free recall test seemed unlikely to have served as a blocker during the cued retest. The free-recall test did have limitations—the cues available during test, and the time of the test, differed from the cued recall test—but the occurrence of a blocker was expected to be highly correlated with that blocker being output during free recall.

Materials and methods

Participants Sixty Columbia University students, ages 17–34, participated for credit in an introductory psychology course or for pay.

Design The experiment was a 2×2 within-participants design. The factors were Reminder (related or unrelated) and TOT type (blocked or non-blocked). The former was

experimentally manipulated; the latter was a quasi-experimental variable that the participant controlled.

Materials There were 172 questions. Twenty of the questions were created for this experiment. The remaining 152 were selected from the set used in Experiment 1 based on their relatively high rates of TOTs and blockers in Experiment 1 and three unpublished experiments.

In Experiment 2, it was necessary to create a cover story to explain why, during the retest, a single word was presented before each question. Introducing these words for the first time during the retest would have surprised participants and put them on their guard; to avoid this, instead of only showing a word before each question on the retest, a word was shown before each question throughout the entire experiment. Furthermore, if the words and questions had all been unrelated during the first part of the experiment, participants might been surprised when this was suddenly no longer the case on the retest (when the participant's own blockers were presented, for example). Thus to convince participants that nothing unusual was happening during the retest, the word and the question it followed were related on some trials during the first part of the experiment.

To accomplish this, we developed a set of two words to be associated with each question, one related and one unrelated. The related word was selected because it was the most common incorrect answer given by participants in previous experiments. These words could be related to the question either semantically, phonologically, or both. Words that started with the same first phoneme or rhymed with the answer were excluded, because they might have served as hints. A semantically related word was selected when no incorrect answer had been given in previous experiments. The unrelated word was selected to be different from the answer both semantically and phonologically, and, to the extent possible, to be different from all of the answers in the question set. For example, one question was "What is the name of the poet who originally wrote 'Don Juan'?" The correct answer is Byron; the related word was Cervantes, and the unrelated word was Petrol.

Procedure The experiment began with instructions; the definitions of TOT, blocked TOT, and non-blocked TOT in the instructions were the same as in Experiment 1, and again participants were told that the questions were hard and some people do not experience a lot of TOTs. As a cover story, explaining why words were presented in between questions throughout the experiment, participants were told a word would be presented on each trial, and that they should memorize the words for a future memory test (and as promised, they were tested on the words at the end of the experiment). The experiment lasted approximately 35 min, and consisted of three phases: Initial test, retest, and free recall.

During phase 1 (initial test), each trial began when a trivia question was presented for 6 s, during which time a button labeled "Got it!" was visible on the screen. If the participant knew the answer to the question, they pressed "Got It," typed the answer in, and the question portion of the trial ended. If, after 6 s, the "Got it" button had not been pressed, it disappeared and two new buttons appeared, labeled "TOT" and "Not a TOT".

If the participant pressed "Not a TOT", the question ended. If they pressed "TOT", two new buttons labeled "True" and "Blocked" were shown, along with the label "The cause of my TOT is —." (Note that participants were being asked what they *thought* the cause of their TOT was—the *actual* cause of retrieval difficulty during TOTs was the topic under investigation.) If the participant pressed "Blocked," they were asked to type in their blocker. After typing in their blocker, or if they pressed "True," they were asked to "Rate your confidence that you know the answer" on a line labeled "Unsure" on one end and "Very

sure" on the other. (Typing in the blocker and the confidence rating were both elements of Experiment 2 that were not included in Experiment 1). After the confidence rating, the question portion of the trial ended.

A word was presented after each question during phase 1. This was different from the retest (phase 2); during the retest, the word associated with a given question was presented before the question, not after. We felt that during the retest participants would be unlikely to notice this difference, and even if they did it would not unduly affect them. Moreover, presenting the related word before the question during phase 1 would have influenced participant responses, and presenting it afterward instead allowed us to avoid that problem. Thus during phase 1, 15% of the questions were followed by their correct answer (although the participant was not told the answer was correct), 15% were followed by words similar to the answer but incorrect, and 70% were followed by unrelated words. These percentages were the same regardless of whether or not the participant reported a TOT. Only questions followed by an unrelated word were included in the analyses.

Phase 2 was the crucial retest. During the retest, questions that had elicited TOTs during phase 1 were repeated. In the Unrelated condition, the questions were preceded by an unrelated word. In the Reminder condition, the question was preceded by the blocker the participant had reported during phase 1, or, if the participant had not reported a blocker, the most common incorrect answer given in previous experiments.

Phase 3, the free recall test, began immediately after the retest (phase 2) ended. Participants were given 5 min and asked to free-recall all of the blockers they had experienced. This served as a measure of the occurrence of blockers during the retest, based on the reasoning that a word that had blocked participants on the retest would be relatively easy to remember on the free recall test, whether it had been presented as a reminder or not. Participants were also asked, as the initial instructions said they would be, to recall the words that had been interleaved throughout the experiment. Both types of words were to be recalled during the same 5-min period.

Results and discussion

Thirteen participants' data could not be analyzed because they did not report at least two blocked and two non-blocked TOTs, leaving 37 participants in the analyses. TOTs were reported on 17% of trials, and of those 43% were blocked. On the free recall test at the end of the experiment, participants recalled more blockers (48%) when they were reminded of them than when they were not (32%), $t(36)=2.12$. To the extent that the free recall test serves as a proxy for the cued recall that immediately preceded it, this establishes that the delay manipulation used in Experiment 1 and 2 was successful in making participants forget at least some of their blockers by the time of the delayed retest.

Turning to resolution rates (see Fig. 2), the blocking hypothesis predicted that being reminded of an otherwise forgotten blocker would decrease resolution rates. Instead, there was no main effect of Reminders on resolution, $F(1,36)=0.02$, $MSE=0.073$, $ES=0.001$, and the interaction between TOT type and Reminders was not significant, $F(1,36)=0.96$, $MSE=0.046$, $ES=0.026$. More importantly, in the blocked condition, a planned comparison of the Unrelated and Reminder conditions was not significant, $t(36)=-0.69$. Like Experiment 1, the difference was neither close to significant nor in the direction predicted by the blocking hypothesis. Thus reminding participants of their blockers did not affect TOT resolution, despite the fact that reminders significantly increased participants' memories for their blockers at the time of the free-recall test. In contrast to Experiment 1, blocked TOTs were

not harder to resolve than non-blocked TOTs overall, $F(1,36)=1.55$, $MSE=0.052$, $ES=0.04$. However, the Unrelated condition is most similar to Experiment 1 and previous experiments on blocked TOTs, and a planned comparison showed that blocked TOTs were resolved less than non-blocked TOTs, although the effect was only marginally significant, $t(36)=-1.68$, $p=0.10$.

Like Experiment 1, blocked and non-blocked TOTs did not differ in question difficulty, $t(36)=0.18$, based on Nelson and Narens's (1980) difficulty norms. Confidence ratings, however, were significantly lower when participants were blocked than when they were not, $t(36)=-2.97$. It may be that participants gave lower ratings because they were blocked, or it may be that they gave lower ratings because the blocked questions were more difficult than the non-blocked questions (for the participant answering them). The latter conclusion is supported by the fact that confidence ratings accurately predicted retest performance—lower confidence was associated with lower rates of TOT resolution on the retest. The mean Gamma correlation between confidence and accuracy was positive in the blocked condition, $M=0.61$, $t(24)=5.65$, and the non-blocked condition, $M=0.40$, $t(24)=3.64$. These correlations did not differ significantly, $t(24)=1.28$. (The correlational analyses required at least one correct and one correct response in both the blocked and non-blocked condition; only 25 participants satisfied this requirement.) A speculative conclusion from the finding that the confidence judgments were highly accurate in both conditions, and that the judgments were lower in the blocked than non-blocked condition, is that perhaps the ratings were accurate, and that the blocked questions were actually more difficult than the non-blocked questions for the particular participant answering them.

In summary, Experiment 2 indicates that the delay used in Experiments 1 and 2 was successful in making participants forget their blockers. Contrary to the blocking hypothesis, however, being reminded of otherwise forgotten blockers did not diminish participants' ability to resolve their TOTs. Finally, blocked TOTs were given lower confidence ratings than non-blocked TOTs, indicating that blockers may have been reported on questions that were especially difficult for the participant.

Fig. 2 Proportion correct on the retest for questions on which participants reported TOTs (i.e., proportion resolved) in Experiment 2. Scores are reported as a function of whether or not participants reported experiencing a blocker, and whether or not they were reminded of their blocker (or shown a related word when there was no blocker) immediately before the retest. *Error bars* represent standard errors
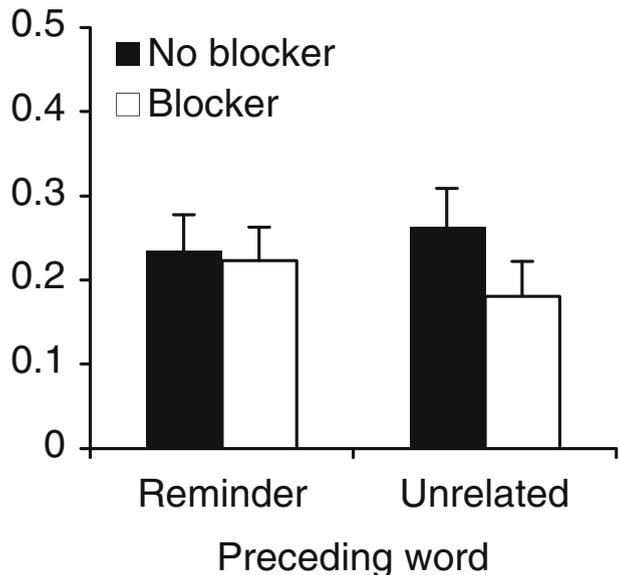
General discussion

The experiments presented here provide no support for the widely accepted view that naturally occurring blockers cause retrieval difficulty during TOTs. In Experiment 1, delay increase resolution rates overall—an incubation effect—but delay did not improve TOT resolution any more for blocked TOTs than it did for non-blocked TOTs, contrary to the blocking hypothesis. The delay did cause at least some blockers to stop coming to mind, however, as shown by Experiment 2. Experiment 2 also showed that reminding participants of forgotten blockers did not hinder TOT resolution, again in opposition to the blocking hypothesis.

Participants resolved fewer blocked TOTs than non-blocked TOTs (see Burke et al., 1991; Reason & Lucas, 1984 for similar findings). The experiments presented here highlight the fact that this correlation does not necessarily indicate that the blockers *cause* retrieval difficulty. Instead, perhaps retrieval difficulty causes blockers. William James described the TOT state as "a gap that is intensely active" (James, 1890, p. 251). Blockers may simply fill the gap in consciousness left by extended, unsuccessful memory search.

If blockers are a side effect, not a cause, of retrieval difficulty, one might predict that blockers should occur on especially difficult questions for the participant—because it is those questions that lead to extended memory search. There was, however, no difference in normative difficulty between blocked and non-blocked questions in the current experiments. It is not the normative question difficulty that is critical for TOTs, however—in fact most TOTs are temporary memory lapses for questions one knows the answer to (Burke et al., 1991). Instead, perhaps confidence ratings are a better way of assessing difficulty during TOTs, because they are particular to the participant at the time of the TOT. This is especially true when the confidence ratings are accurate, as they were in Experiment 2. As measured by confidence ratings, blocked TOTs were more difficult than non-blocked TOTs. This suggests the possibility that blocked TOTs were resolved less often than non-blocked TOTs because blockers occurred on especially difficult questions for the participant at the time, not because the blockers caused retrieval difficulty. It should be noted, however, that Burke et al. (1991) did not find differences in ratings of certainty-of-recall between blocked and non-blocked TOTs.

TOTs were more likely to be resolved after a delay than immediately in Experiment 1. This replicates Choi and Smith (2005), although those authors hypothesized that the effect was caused by a release from blockers—a hypothesis directly tested, but not supported, by the experiments reported here. While incubation effects are generally elusive (Kaplan & Simon, 1990; Smith, 1994), the current findings indicate that incubation has a replicable benefit during TOTs. The findings are consistent with partial activation theory, which posits that delay should increase TOT resolution if it involves encountering sounds that were not activated during the initial TOT (Burke et al., 1991; James & Burke, 2000). Answering additional trivia questions is likely to activate such sounds (although in the current experiments the particular sounds participants encountered were not controlled). Metacognitive control theory (e.g., Schwartz, 1999, 2001, 2002a) may need to be amended to explain TOT incubation effects, although it does not make strong predictions about the effects of delay.

The explanation of the incubation effects need not be limited to TOTs. Indeed, it is possible that in the current experiments, incubation effects would have occurred on non-TOT questions if they had been retested (although even at a delay, resolution rates would have been low; James & Burke, 2000; White & Abrams, 2002). As such, instead of being explained by TOT theories, perhaps these effects are better explained by more global memory mechanisms (including partial activation theory and related theories), which also play a role in related phenomena such as reminiscence effects (e.g., Smith & Vela, 1991).

The evidence presented here indicates that consciously experienced memory blocks do not cause retrieval difficulty during TOTs. This is different from claiming that blocks do not occur in memory—and a host of experimental findings, for example proactive and retroactive interference, support the idea that memory retrieval can be blocked. Schwartz (1999) has argued that the doctrine of concordance, which is the assumption that conscious experience directly reflects mental processing (Tulving, 1989), has been mistakenly applied to TOTs in the past. Specifically, it may be a mistake to assume that consciously experienced blockers are the same as blockers that have been shown to affect memory unconsciously. Instead, there may be two classes of blockers: those that actually block memory during TOTs, and those that people experience, which do not block. For example Smith and Tindell (1997; see also Logan & Balota, 2003) asked participants to fill in word fragments (e.g., A_L__GY) after showing them either unrelated words or related words (which were meant to serve as blockers). Performance was worse when the related word was shown, even when participants were told to try to ignore the blocker. This was taken as evidence that blockers can hinder recall at an implicit level, which is consistent with the current findings, but leaves open the question of whether consciously experienced blockers affect TOTs.

The fact that people who experience blockers *feel* as though the blockers are blocking them (which informal conversations suggest many do) may itself be a metacognitive illusion. TOTs are accompanied by high feelings of knowing, which are generally accurate, given that people almost always know the answer that they temporarily cannot retrieve, and feelings of imminence, which are accurate on some occasions, and a source of frustration on others (that is, when the TOT is not quickly resolved). The metacognitive belief that a blocker exists may be accurate as well, but the belief that it is actually blocking appears to be illusory.

Occasionally a mistaken belief becomes ingrained in researchers' collective understanding. Blocked TOTs seem to be such a case. In part this may be due to researchers' own (illusory) intuitions that their TOTs are caused by blocks. In any case, previous research has shown that some of the methods originally used to support the role of blockers were flawed (Meyer & Bock, 1992; Perfect & Hanley, 1992), and theoretical treatments of TOTs have successfully predicted many of the findings in the TOT literature without necessitating blockers (e.g., Burke et al., 1991; Schwartz, 2002a). The current findings are direct evidence against the blocking hypothesis. They are not proof (proving a null hypothesis is a tall order), but given the lack of effect of blockers in circumstances under which any effect should have been apparent, the findings indicate that blockers should be considered innocent until proven guilty, and that "blocker" is something of a misnomer.

In summary, the experiments presented here did not support the widely accepted blocking hypothesis, according to which blockers—that is, incorrect answers which come to mind persistently during TOTs—cause retrieval difficulty during naturally occurring TOTs. When participants were retested on a question that elicited a TOT after a delay, they showed significant forgetting of their blockers, but this did not improve TOT resolution any more than when there was no blocker. When participants were reminded of blockers they had forgotten, their recall rates were unaffected.

References

Adamson, R. E. (1952). Functional fixedness as related to problem solving: A repetition of three experiments. *Journal of Experimental Psychology, 44*, 288–291.

Brown, A. S. (1991). The tip of the tongue experience: A review and evaluation. *Psychological Bulletin, 10*, 204–223.

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

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

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

Caramazza, A., & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the "tip-of-the-tongue" phenomenon. *Cognition, 64*, 309–343.

Chan, J. C. K., McDermott, K. B., & Roediger, H. L. III. (2006). Retrieval-induced facilitation: Initially nontested material can benefit from prior testing of related material. *Journal of Experimental Psychology: General, 135*, 553–571.

Choi, H., & Smith, S. M. (2005). Incubation and the resolution of tip-of-the-tongue states. *The Journal of General Psychology, 132*, 365–376.

Duncker, K. (1945). On problem-solving. *Psychological Monographs, 58*, No. 270.

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

James, L. E., & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences in young and older adults. *Journal of Experimental Psychology: Learning, Memory and Cognition, 26*, 1378–1391.

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

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

Jones, G. V., & Langford, S. (1987). Phonological blocking in the tip of the tongue state. *Cognition, 26*, 115–122.

Kaplan, C. A., & Simon, H. A. (1990). In search of insight. *Cognitive Psychology, 22*, 374–419.

Koriat, A., & Lieblich, I. (1974). What does a person in a "TOT" state know that a person in a "don't know" state doesn't know? *Memory & Cognition, 2*, 647–655.

Logan, J. M., & Balota, D. A. (2003). Conscious and unconscious lexical retrieval blocking in younger and older adults. *Psychology and Aging, 18*, 537–550.

Luchins, A. S. (1942). Mechanization in problem solving: The effect of Einstellung. *Psychological Monographs, 54*, No. 248.

Macrae, C. N., & MacLeod, M. D. (1999). On recollections lost: When practice makes imperfect. *Journal of Personality and Social Psychology, 77*, 463–473.

Mayer, R. E. (1995). The search for insight: Grappling with Gestalt psychology's unanswered questions. In R. J. Stemberg & J. E. Davidson (Eds.), *The nature of insight* (pp. 3–32). Cambridge, MA: MIT Press.

Maylor, E. A. (1990a). Age, blocking and the tip of the tongue state. *British Journal of Psychology, 81*, 123–134.

Maylor, E. A. (1990b). Recognizing and naming faces: Aging, memory retrieval and the tip of the tongue state. *Journal of Gerontology: Psychological Sciences, 45*, 215–225.

Metcalfe, J. (1986a). Premonitions of insight predict impending error. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 623–634.

Metcalfe, J. (1986b). Feeling of knowing in memory and problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 288–294.

Metcalfe, J., & Wiebe, D. (1987). Intuition in insight and noninsight problem solving. *Memory & Cognition, 15*, 238–246.

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

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

Nelson, T. O., & Narens, L. (1980). Norms of 300 general-information questions: Accuracy of recall, latency of recall, and feeling-of-knowing ratings. *Journal of Verbal Learning & Verbal Behavior, 19*, 338–368.

Perfect, T. J., & Hanley, J. R. (1992). The tip-of-the-tongue phenomenon: Do experimenter-presented interlopers have any effect? *Cognition, 45*, 55–75.

Read, J. D., & Bruce, D. (1982). Longitudinal tracking of difficult memory retrievals. *Cognitive Psychology, 14*, 280–300.

Reason, J. T., & Lucas, D. (1984). Using cognitive diaries to investigate naturally occurring memory blocks. In J. Harris & P. E. Morris (Eds.), *Everyday memory, actions, and absent mindedness* (pp. 53–70). London: Academic.

Schacter, D. L. (1999). The seven sins of memory: Insights from psychology and cognitive neuroscience. *American Psychologist, 54*, 182–203.

Schwartz, B. L. (1998). Illusory tip-of-the-tongue states. *Memory, 6*, 623–642.

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

Schwartz, B. L. (2001). The relation of tip-of-the-tongue states and retrieval time. *Memory & Cognition, 29*, 117–126.

Schwartz, B. L. (2002a). *Tip-of-the-tongue states: Phenomenology, mechanism, and lexical retrieval.* Mahwah, NJ: Erlbaum.

Schwartz, B. L. (2002b). The phenomenology of naturally-occurring tip-of-the-tongue states: A diary study. In S. Shohov (Ed.) *Advances in Psychology Research* (pp. 71–84). Nova Science Publishers: New York.

Schwartz, B. L., Travis, D. M., Castro, A. M., & Smith, S. M. (2000). The phenomenology of real and illusory tip-of-the-tongue states. *Memory & Cognition, 28*, 18–27.

Smith, S. M. (1994). Frustrated feelings of imminent recall: On the tip of the tongue. In J. Metcalfe & A. P. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 27–46). Cambridge, MA: MIT Press.

Smith, S. M., & Blankenship, S. (1989). Incubation effects. *Bulletin of the Psychonomic Society, 27*, 311–314.

Smith, S. M., & Blankenship, S. (1991). Incubation and the persistence of fixation in problem solving. *American Journal of Psychology, 104*, 61–87.

Smith, S. M., & Tindell, D. R. (1997). Memory blocks in word fragment completion caused by involuntary retrieval of orthographically related primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 355–370.

Smith, S. M., & Vela, E. (1991). Incubated reminiscence effects. *Memory & Cognition, 19*, 168–176.

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

White, K. K., & Abrams, L. (2002). Does priming specific syllables during tip-of-the-tongue states facilitate word retrieval in older adults? *Psychology and Aging, 17*, 226–235.

Widner, R. L., Smith, S. M., & Graziano, W. G. (1996). The effects of demand characteristics on the reporting of tip-of-the-tongue states and feeling-of-knowing states. *American Journal of Psychology, 109*, 525–538.

Woodworth, R. S. (1938). *Experimental psychology.* Oxford, England: Holt.