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Tip-of-the-tongue states predict enhanced feedback processing and subsequent memory

Paul A. Bloom*, David Friedman, Judy Xu, Matti Vuorre, Janet Metcalfe

Columbia University, Department of Psychology, Schermerhorn Hall #406, 1190 Amsterdam Ave, New York, NY, USA

ABSTRACT

This article investigates the relations among the tip-of-the-tongue (TOT) state, event related potentials (ERPs) to correct feedback to questions, and subsequent memory. ERPs were used to investigate neurocognitive responses to feedback to general information questions for which participants had expressed either being or not being in a TOT state. For questions in which participants were unable to answer within 3 s, they indicated whether they were experiencing a TOT state and then were immediately provided with the correct answer. Feedback during a TOT state, as opposed to not knowing the answer, was associated with enhanced positivity over centro-parietal electrodes 250–700 ms post-feedback, and this enhanced positivity mediated a positive relationship between TOTs and later recall. Although effects of increased semantic access during TOT states cannot be ruled out, these results suggest that information received during TOT states elicits enhanced processing—suggestive of curiosity—leading to enhanced learning of studied material.

1. Introduction

The tip-of-the-tongue (TOT) state is often a highly frustrating phenomenon. Described as “a gap that is intensely active” (James, 1890, p. 251) or as “personal introspections of inner turmoil when grappling for an elusive word," (Brown, 1991, p. 205) TOT states are defined as the simultaneous feeling of being unable to recall an item, and confidence that one could recall, given enough time (Schwartz, 2006). According to metacognitive models, the TOT state is analogous to a “low tire pressure” signal in a car in that it alerts one about a problem (failed recall); yet it is not the problem itself (Schwartz & Metcalfe, 2011). While a low tire pressure signal serves to remind car owners to inflate their tires, the function of the TOT state is more opaque. As TOT states have been associated with curiosity for un-retrieved information (Metcalfe, Schwartz, & Bloom, 2017), it may be the case that TOTs function as a signal to amplify processing when feedback, in the form of the target of the failed recall attempt, is provided. In the present research, we investigated whether TOT states function to aide learning, and whether such learning is mediated by enhanced processing of external feedback.

Apart from curiosity specifically, TOTs have been identified in several contexts as motivating cognitive processes. One possible function for TOTs is to drive retrieval attempts, and indeed several studies have found that individuals devote more resources towards retrieving items while they are experiencing TOT states (Kikyo, Ohki, & Sekihara, 2001; Schwartz, 2001). For example, individuals spent more time attempting to recall answers while in TOT states than when they were sure they did not know the answers (Schwartz, 2001). When participants were given a secondary working memory task in addition to TOT-eliciting cues, performance was poorer on the secondary task for trials in which TOT states were experienced, suggesting greater devotion of cognitive resources to memory search processes (Ryan, Petty, & Wenzlaff, 1982).

* Corresponding author.
E-mail address: pab2163@columbia.edu (P.A. Bloom).

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In addition to motivating retrieval efforts, TOT states have also been suggested to drive curiosity as operationalized by answer-seeking (i.e., either looking up the answer or asking for the answer). Litman, Hutchins, and Russon (2005) gave participants a series of 12 general information questions, and for each asked participants whether they knew the answer, they didn't know the answer, or they were in a TOT state. When participants were later allowed to open envelopes containing answers to these same questions, the researchers reported that participants were more likely to choose questions about which they had earlier been in a TOT state than those about which they were not in a TOT state. These findings were limited by the small number of questions used per participant (and the small number of TOT states) and by the long time period between the experience of being in the TOT state and the choices. In a subsequent study (Metcalfe et al., 2017) using many more questions (82) with very little time to attempt retrieval (resulting in all participants experiencing TOT states), and also requiring participants to choose immediately – while they were still in a TOT state – participants were approximately twice as likely to choose to see the TOT state-related answers than the non-TOT state answers, indicating that TOTs are associated with elevated curiosity for target items.

Indeed, TOTs seem to fit within Berlyne's (1954) theory of epistemic curiosity, which posits that the items that are almost known are the ones which most spark human interest. Epistemic curiosity's function is thought to be a motivator to close the gap between what one knows and what one desires to know (Berlyne, 1954, 1960; Litman & Spielberger, 2003; Loewenstein, 1994), with items that are perceived to be almost known being those most likely to provoke such curiosity. Indeed, when individuals were presented with learning tasks, they chose to spend more time studying items that were within a "region of proximal learning," (RPL) which is defined as consisting of those as-yet-unlearned items with the highest judgments of learning (Metcalfe & Kornell, 2005; Metcalfe, 2002). In addition, individuals mind-wandered less when studying items they judged to be within their RPL, as compared to items that were perceived to be either too easy or too difficult (Xu & Metcalfe, 2016). It may be possible to conceptualize the TOT state as a marker that the unrecalled information resides within an RPL-like domain: between information that is already well known and that which is completely unfamiliar. It thereby elicits a high degree of curiosity.

Curiosity has also been linked to enhanced subsequent memory. In an fMRI study, Kang et al. (2009) administered general information questions to participants and probed for their curiosity on each question. When the experimenters provided participants with correct answer feedback, answers to curiosity-evoking questions were associated with activation in the left inferior frontal gyrus (IFG) and left parahippocampal gyrus (PHG), regions believed to be active in verbal memory encoding (Paller & Wagner, 2002; Wagner et al., 1998). In a follow-up behavioral experiment, feedback following incorrect answers about which the participant was curious was better recalled than feedback about errors about which the participant had not been curious. While the researchers did probe participants as to whether they experienced TOTs, participants did not report enough TOT states for analysis under this paradigm.

If the TOT state is, itself, a marker of curiosity, then memory may also be better for feedback provided when the learner is in a TOT state. Supporting this idea, Gardiner, Craik, and Bleasdale (1973) found improved subsequent memory for items for which participants had been in a TOT, compared to those items for which participants were not in a TOT. They suggested that TOT states enhance processing, either through increasing the amount of attention devoted to feedback or by activating more semantic attributes of the target word. MacKay and Burke (1990) have suggested that TOTs occur when considerable semantic information about a target is available, and yet the phonological information is insufficient to allow production of the name (also see, Burke, MacKay, Worthley, & Wade, 1991). It is well documented that individuals have partial information about the target when they are in a TOT state: they can often recall the first letter (Brown & McNeill, 1966; Koriat & Lieblich, 1974), the number of syllables (Burke et al., 1991), and even the grammatical gender of the word (Miozzo & Caramazza, 1997). Furthermore, given sufficient time they can sometimes recall the target (Cohen & Faulkner, 1986). Thus, as noted by Gardiner et al. (1973), it is likely that this partial information, as well as TOT-related increases in attention, contributes to the high rates of recall for TOT-evoking items. We further explore this relation between TOT states and subsequent memory, and the possibility that people's event-related potentials (ERPs), while receiving feedback when they are either in a TOT state or not, may shed light on this relation.

There is a substantial body of work showing that distinct neural patterns during learning can be found based on whether items are successfully recalled in a subsequent test. In particular, ERPs for later remembered items tend to display heightened late positivity during learning compared to those that are forgotten (Fabiani, Karis, & Donchin, 1990; Friedman & Johnson, 2000; Friedman & Trott, 2000; Friedman, 2003; Friedman, Ritter, & Snodgrass, 1996; Paller, Kutas, & Mayes, 1987; Paller, McCarthy, & Wood, 1988; Sanquist, Rohrbaugh, Syndulko, & Lindsley, 1980). This enhanced processing for subsequently remembered items, named the difference in memory effect (Dm; Paller et al., 1987), has been found with a variety of learning tasks, and with both words (Fabiani & Donchin, 1995; Fabiani, Karis, & Donchin, 1986) and pictures (Friedman & Sutton, 1987) as stimuli.

While Dm effects show a consistent pattern such that subsequently remembered items are associated with more positive ERP amplitudes, the latency and scalp distributions of such effects vary with the task and stimuli such that the effect has been recorded over frontal (Friedman, 1990; Münte, Heinze, Scholz, & Künkel, 1988; Paller & Kutas, 1992; Sanquist et al., 1980), central (Paller, 1990), and parietal electrodes (Paller & Wagner, 2002; Paller et al., 1987; Weyerts, Tendolkar, Smid, & Heinze, 1997). In addition, while some Dm effects resemble the P300 component elicited by novel items (Wagner, Koutstaal, & Schacter, 1999), the heightened positivity for subsequently recalled items in many cases persists much longer, up to 900–1000 ms post-stimulus, than the typical P300 (Friedman & Sutton, 1987; Smith, 1993). Furthermore, as demonstrated by Friedman (1990), the subsequent memory effect may be dissociated from the P300 with which it overlaps by differences in scalp distribution between the two components. The heightened ERP amplitudes for later remembered items are thought to reflect enhanced encoding, as items subject to deep semantic processing display larger Dm effects than items processed in a shallow non-semantic fashion (Paller et al, 1987). Further, Wagner et al. (1999) suggested that in some instances, subsequent memory effects depend on the existence of prior knowledge that individuals can incorporate into their representations of the current stimuli. Because TOT states are thought to involve a high degree of prior knowledge (Schwartz & Metcalfe, 2011) or semantic access (Burke et al., 1991), it may be the case that the differential processing of