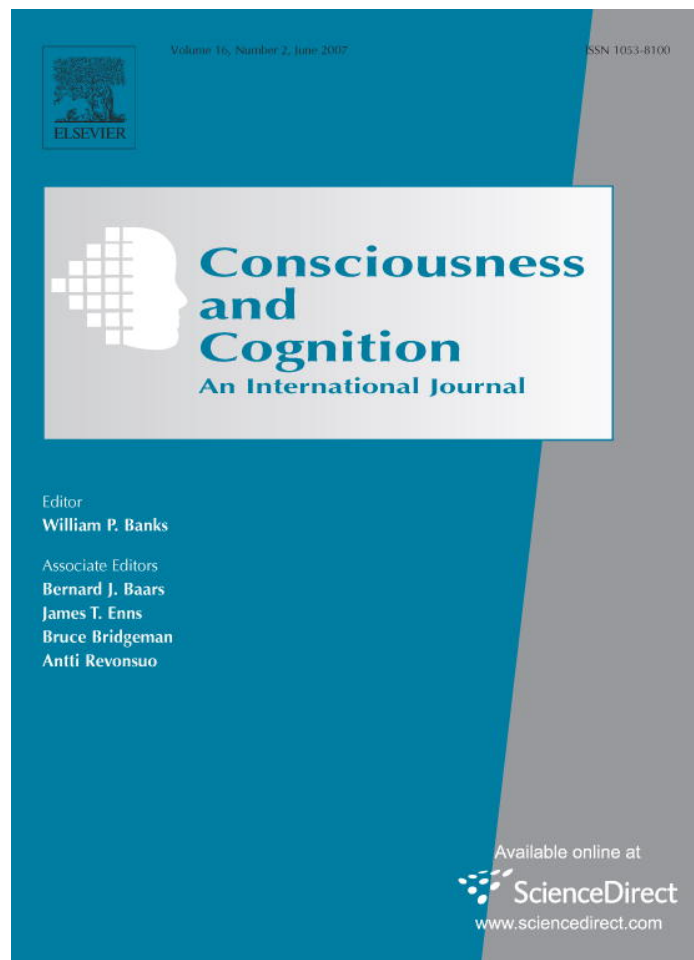


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# Dissociation between the cognitive process and the phenomenological experience of TOT: Effect of the anxiolytic drug lorazepam on TOT states

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## Abstract

TOT states may be viewed as a temporary and reversible microamnesia. We investigated the effects of lorazepam on TOT states in response to general knowledge questions. The lorazepam participants produced more commission errors and more TOTs following commission errors than the placebo participants (although the rates did not change). The resolution of the TOTs was unimpaired by the drug. Neither feeling-of-knowing accuracy nor recognition were affected by lorazepam. The higher level of incorrect recalls produced by lorazepam participants may be due to the fact that they were more frequently temporarily unable to access a known item. For some of these items, the awareness of the retrieval failure resulted in a commission TOT (phenomenological TOT after a commission error). The resolution of the TOT conflict is discussed in the light of the anxiolytic and anticonflict effects of lorazepam. The data are discussed in terms of contemporary theories of TOTs and the effects that benzodiazepines have on semantic memory.

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## 1. Introduction

Healthy people occasionally experience ordinary memory failures at some time or other (Schacter, 1999). Some of these common memory failures are permanent. For example, you will almost certainly never remember what you ate for dinner on 7th June 2005. However, other impairments often prove to be transient. Indeed, it is possible to view tip-of-the-tongue states (TOTs) as temporary and reversible amnesic episodes. TOTs have recently gained importance in a number of areas within the field of cognitive psychology (e.g.,

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Choi & Smith, 2005; Gollan & Acenas, 2004; Hamberger & Seidel, 2003; Lesk & Womble, 2004; Maril, Simon, Mitchell, Schwartz, & Schacter, 2003; Maril, Simons, Weaver, & Schacter, 2005).

A TOT is a state in which a target word is not retrieved but in which the participant feels that he or she knows and will retrieve the target word. TOT experiences tend to be accurate as they predict recognition and recall (see Schwartz, 2002a). Moreover, diary studies show that 89–95% of missing words are subsequently retrieved by the participant in real-world TOTs (Burke, MacKay, Worthley, & Wade, 1991; Ecke, 1997; Schwartz, 2002b; for a review, see Brown, 1991; Schwartz, 2002a).

Diary studies and laboratory tasks also show that 50–70% of TOTs are accompanied by persistent alternates, also known as blockers and interlopers (Burke et al., 1991; Reason & Lucas, 1984). Burke et al., found that nearly 90% of the persistent alternates were from the same syntactic category as the missing word. Although these alternates are recognized as incorrect, the participants are unable to retrieve the correct target. However, in these field studies, it is not possible to collect comparable states of unretrieved words which are not in TOT states (referred to as n-TOTs below). Laboratory studies reveal higher rates of both resolution and persistent alternates among TOTs than n-TOTs (Smith, 1994). In the current study, we examine the role that persistent alternates play in the production of TOTs by using a pharmacological tool that should provide us with an insight into this phenomenon.

We make a distinction between two aspects of the TOT phenomenon. First, we define the cognitive state involved in TOTs as being the failure of the retrieval process to produce a known word (e.g., Burke et al., 1991; Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997). This cognitive process relates to word retrieval and its failure. In contrast, we define the phenomenological experience of the TOT as the strong and frustrating feeling that a particular target word is about to be retrieved (e.g., Brown & Mc Neill, 1966; Schwartz, Travis, Castro, & Smith, 2000). This experience is metacognitive in nature since it involves a feeling of a future capability to remember.

We argue that the literature supports the idea of this type of distinction between cognitive and phenomenological TOTs (see Schwartz, 2002a). The research suggests that not all temporary retrieval failures are accompanied by TOTs, in the same way that not all phenomenological TOTs are accompanied by the ultimate retrieval of the target (e.g., Schwartz, 1998; Schwartz et al., 2000). Furthermore, research has demonstrated dissociations between retrieval and the number of TOTs (e.g., Schwartz & Smith, 1997; Widner, Smith, & Graziano, 1996). Thus, throughout this paper, we use the term *cognitive TOT*—or simply *retrieval failure*—to refer to the temporary amnesia associated with the failure to retrieve a known word and the term *phenomenological TOT* to refer to the subjective experience of feeling that a word is retrievable. In this study, we show that, in some cases, phenomenological TOTs do not occur until after the participant has found out that his or her retrieval was inaccurate. Thus, we will argue in support of a model of TOTs that makes a distinction between the cognitive and phenomenological aspects of the TOT process (for an opposing view, see Taylor & MacKay, 2003).

### 1.1. Benzodiazepines and memory

Amnesia-inducing drugs can be used as tools to reveal the functional principles of normal cognitive processing (Danion, 1994). In this paper, we concentrate on whether or not benzodiazepines affect semantic memory. Curran (1991, 1999) has argued that benzodiazepines do not alter semantic memory. These conclusions were primarily drawn on the basis of unimpaired performances in verbal fluency tasks in which participants were required to provide in a fixed time either the largest possible number of items belonging to a given semantic category (Curran, 1991; File, Sharma, & Shaffer, 1992; Fluck et al., 1998; Vermeeren et al., 1995). Allen, Curran, and Lader (1993) and Green, McElholm, and King (1996) found that lorazepam did not affect the accuracy of semantic retrieval.

However, other evidence obtained from sentence verification tasks suggests that semantic memory may be affected by benzodiazepines. Vermeeren et al. (1995) reported that lorazepam-treated participants made more errors than did placebo participants. In addition, File et al. (1992) showed that the benzodiazepine, midazolam, impaired word completion performance. They observed that participants who had been administered benzodiazepine generated more low-frequency exemplars than common words when retrieving categorical information from memory. This may reflect the fact that the “ordinary” high-frequency answers were

temporarily inaccessible, and that the participant had to call on more uncommon words to complete the task. In another type of semantic memory task assessing the answers to general knowledge questions (e.g., what is the color of emerald?), Bacon and her colleagues observed that participants under the effect of lorazepam produced as many recall answers as did the participants who were receiving a placebo, but that the proportion of incorrect answers was higher (commission errors) (Bacon et al., 1998; Izaute, Paire-Ficout, & Bacon, 2004; Massin-Krauss, Bacon, & Danion, 2002). Furthermore, the lorazepam participants were more susceptible to a common semantic illusion known as the Moses Illusion (Izaute et al., 2004). The observed semantic impairment was an effect of the amnesic drug since the participants in the last two experiments (2002 and 2004) had been pseudo-randomly assigned to one of the two groups (placebo or lorazepam) on the basis of their pre-drug general knowledge.

### 1.2. Benzodiazepine and metamemory

Bacon et al. (1998) and Massin-Krauss et al. (2002) asked their participants to rate their retrospective confidence level (CL) that the answer they had provided was correct. Both studies observed that participants under lorazepam selectively overestimated their CL judgements for their incorrect recalls compared to the CL judgments of placebo participants. However, they were still able to discriminate between correct and incorrect answers, as their confidence remained higher for correct than for incorrect answers. At the same time, the accuracy of their CL estimations as well as the predictive accuracy of their FOK estimations regarding future recognition performance, (i.e., their  $\gamma$  correlations Nelson, 1984) did not differ from those of the participants who received a placebo. The preservation of monitoring accuracy while under the effect of lorazepam suggests that some of the monitoring abilities are relatively spared by the amnesic drug.

This impaired recall performance may suggest that lorazepam affects the control processes. The drug may perhaps induce a disinhibitory state that leads participants to produce answers that they might otherwise have kept to themselves. If this is indeed the case, we would expect lorazepam participants to provide more recall answers than their placebo counterparts in a free recall task. However, the number of answers produced by the lorazepam participants did not differ from the placebo condition (Bacon et al., 1998), a fact which casts some doubt on this interpretation. In addition, Massin-Krauss et al. (2002) examined the effects of lorazepam on the processes involved in the strategic regulation of memory accuracy (Koriat & Goldsmith, 1996). They showed that not all the extra commission errors produced under the effect of lorazepam in a semantic task can be the result of a criterion shift (a lowering of the response criterion setting, i.e., the confidence threshold for volunteering an answer: Koriat & Goldsmith, 1996).

The amnesic episode induced by benzodiazepines is transitory and lasts only for a few hours (for a review see Curran, 1999). In the case of semantic memory, the impairment is necessarily reversible: benzodiazepines are the most commonly consumed drugs in the western world because of their effects on anxiety, insomnia and muscle relaxation (Kaplan, 2005) and any resulting semantic impairment would most certainly have been observed in the clinical environment!

We have shown that lorazepam creates a reversible semantic memory impairment while also permitting the relative preservation of decision-making abilities. We therefore asked why lorazepam participants provide incorrect recall answers. Furthermore, under what circumstances is the memory of healthy participants temporarily impaired in such a way that they are induced to provide an incorrect answer when they actually know the correct answer?

### 1.3. The potential effects of lorazepam on TOTs

While in a TOT state, participants are temporarily unable to recover known information and may sometimes retrieve a persistent alternate. Thus, the TOT state is similar, at least superficially, to the symptoms induced by lorazepam. However, there are two striking differences between what occurs in participants experiencing temporary amnesia during a TOT and participants experiencing temporary amnesia under the effect of a benzodiazepine. First, when they produce incorrect recalls, lorazepam participants do not know that the item is a persistent alternate and they do not experience a phenomenological TOT. Second, the effect of the lorazepam increases the likelihood that participants will report the persistent alternate as an answer (i.e.,

commission error). Lorazepam participants do, however, experience the phenomenology of TOT after a number of retrieval failures (unpublished data from Massin-Krauss et al., 2002). We wondered if the cognitive processes of participants under the effect of lorazepam might resemble those of a TOT (that is to say the temporary failure to retrieve a known word) but in the absence of the TOT phenomenology. If this were the case, they would not reject the persistent alternate and would propose it as the target without, however, recognizing the nature of this response. However, after having been identified as a commission error, the salience of the item may cause the TOT phenomenology to emerge.

Retrieval failures accompanied by phenomenological TOTs may be relatively stressful events which are often accompanied by a sensation of frustration (Schwartz et al., 2000). Given that benzodiazepines act as anxiolytic drugs and are acknowledged as having anticonflict effects (Harvey, 1980; Kleven & Koek, 1999; Vanover, Robledo, Huber, & Carter, 1999), it is reasonable to suspect that they might exert some effect on the phenomenological TOT and its relation to any stressful aspect of the cognitive conflict initiated by this process. As a result, we suspect that the anxiolytic effect of lorazepam could induce a state in which participants are not aware of the phenomenological TOT during retrieval failure. They would consequently volunteer the persistent alternate as a convenient answer to the question. This view suggests that lorazepam diminishes the phenomenological experience of TOTs while also increasing the number of retrieval failures (incorrect reporting of persistent alternates). In the experiment reported here, we investigated the effect of lorazepam on cognitive and phenomenological TOTs using the experimental paradigm proposed by Schwartz et al. (2000) which makes it possible to examine TOTs after commission errors.

#### 1.4. Additional results reported by Bacon et al. (1998) (unpublished data)

Before exploring the effects of lorazepam on TOTs under experimental conditions, we analyzed unpublished data reported by Bacon et al. (1998) in order to examine two memory and metamemory features which are of relevance to our hypotheses concerning the effect of lorazepam on TOTs, namely the nature of the incorrect recalls and the underlying nature of the monitoring abilities. One of the objectives of our re-analysis of Bacon et al. (1998) was to determine whether the incorrect recalls provided under the effect of lorazepam resembled the persistent alternates found in TOTs. Our second objective was to determine whether certain general characteristics of monitoring are preserved under the effect of lorazepam, and particularly whether participants who have been administered lorazepam can still use inferential processes to make feeling-of-knowing judgments (referred to as FOKs below). (The data are available on request from the first-mentioned author).

In the study, the recall judgment recognition (RJR) paradigm was used (e.g., Hart, 1965). Twelve placebo participants, and 12 lorazepam participants (0.038 mg/kg) were presented with 120 general knowledge questions and were asked to recall the answers. The mean number of answers provided during the recall phase per participant was similar in the placebo and the lorazepam groups. However, the number of incorrect answers was higher in the lorazepam group (for details, see Bacon et al., 1998).

The first new analysis required us to examine the commission errors in order to provide additional information about the lexical retrieval process in participants under lorazepam. The commission errors were analyzed on the basis of to four criteria: semantic substitutions, phonological or semantic-phonological substitutions, perseverative errors and commission errors without any apparent link, and invented words. The majority of the errors were semantic in nature in both groups and the proportion of semantic errors did not differ at a significant level,  $t(22) = 1.3$ ,  $p = .19$ . Overall, the participants under lorazepam produced commission errors that resembled the persistent alternates observed in the TOT literature (Burke et al., 1991; Harley & Bown, 1998).

In a by-item analysis, we observed that the total number of questions that resulted in at least one incorrect recall response was higher in the lorazepam group than in the placebo group. The 12 participants in the lorazepam group made commission errors on 105 questions and provided 235 *different* wrong answers to this set of questions whereas the 12 placebo participants produced only 106 different wrong answers on 67 questions out of the entire set of 120 questions. This indicates that more questions were capable of inducing lorazepam participants to make recall errors, with the possible incorrect answers being more diverse. This indicates that, under the effect of lorazepam, the questions lead to the retrieval of information relevant to the target (Koriat,

1995) and that lorazepam participants do not inhibit incorrect answers when they are retrieved. However, it should be remembered that the mean number of recall answers provided by each participant did not vary with the lorazepam intake. Lorazepam may subsequently impair the semantic treatment of the question and induce the participants to provide an incorrect answer instead of the correct response on some trials, but would not result in a behavioral disinhibition that would have led each lorazepam participant to provide more recall answers than the placebo participants.

We also asked two questions intended to examine the preservation of the role of cue familiarity and inferential processes in the feeling-of-knowing judgments (FOK) of participants under lorazepam (Costermans, Lories, & Ansay, 1992; Metcalfe, Schwartz, & Joaquim, 1993). According to the inferential process model, the monitoring of knowledge is based on heuristic processes in which certain cues are used consciously or unconsciously to form a judgment about the likelihood that the inaccessible target is known by the participant (Nelson & Narens, 1990). Inferential processes may also be related to general properties of the questions, such as familiarity with the general topic addressed by the item (e.g., I do not know much about Swedish history) (Costermans et al., 1992) or the retrieval of pertinent episodic information (e.g., remembering particular events surrounding information acquisition) (Metcalfe et al., 1993; Koriat, 1994). According to Koriat (1993, 1995), FOK judgments are dependent on information accessibility, i.e., simply on the quantity of the accessible information.

In an initial question, we hoped to examine the identification of the particular circumstances surrounding the possible acquisition of the sought information (*Q1: Do you remember any particular circumstances in which you could have come across this fact*). The second question required the participants to assess their familiarity with the question (*Q2: Is this domain familiar to you?*). The ratings for both questions were significantly correlated with FOK ratings but the  $\gamma$  correlations did not vary significantly across groups. These data suggest that lorazepam spares the processes underlying monitoring, i.e., the inferential processes that are based on the general properties of the questions such as their familiarity with the subject and the retrievability of events.

To summarize, the additional analyses of the Bacon et al. (1998) experiment revealed that the lorazepam participants made commission errors that were mostly semantically related to the target. Finally, the accessibility to knowledge about the subject of each question and general inferential abilities seemed to be preserved by the amnesic drug.

### 1.5. Hypotheses for the current experiment

In this study, we investigated the effect of Lorazepam on TOTs. In previous experiments, lorazepam participants have been shown to produce more commission errors (Bacon et al., 1998; Izaute et al., 2004; Massin-Krauss et al., 2002). We examined the possibility that participants under lorazepam may retrieve a persistent alternate which they output while the actual answer is temporarily inaccessible to them (Brown, 1991). We also suspect that participants may not spontaneously experience TOT phenomenology. However, after being informed that their answer is not correct, lorazepam participants could experience TOTs on some of the corresponding items just as normal participants do. Thus, the purpose of this study was to see if participants under lorazepam experience more phenomenological TOTs after commission errors (i.e., commission TOTs) than do control participants.

In line with the results obtained in previous experiments, we suspect that lorazepam will prevent the occurrence of TOT phenomenology after a retrieval failure accompanied by the production of an incorrect answer. Consequently, the consumption of lorazepam is expected to prevent TOT phenomenology only after a commission error has been made. The anticonflict effect of the benzodiazepine may prevent the TOT phenomenology from occurring simultaneously and cause participant to propose this incorrect word as the proper answer. The participant would not be aware of his/her present state of retrieval failure, and would improperly attribute the confidence he/she has in the correct answer to the persistent alternate. Thus, participants should be more likely to produce persistent alternates as the correct answer, as suggested by the earlier study. However, after the participants receive feedback indicating that the produced answer was incorrect, then it is probable that we will observe TOT phenomenology for the commission errors (i.e., a commission TOT).

We therefore make the following hypotheses. We hypothesize that we will reproduce previous observations of a greater number of commission errors in lorazepam participants. We also expect participants under lorazepam to experience TOT phenomenology after a commission error more frequently when they are informed that the answer that they provided is not the right one. If lorazepam has only a quantitative effect on the naturally occurring semantic errors, then the ability of the participants receiving lorazepam to resolve the TOT errors should parallel that of the placebo participants, and their other metacognitive abilities related to the FOK should be equivalent. The subsequent resolution ability (the recovery of the correct answer after having experienced a TOT) will also be investigated using a recognition task. If lorazepam has a specific amnesic effect on semantic memory, then the possible resolution of the TOTs could also be impaired relative to the control condition because the recognition phase occurs while the participants are still under the effect of lorazepam.

## 2. Materials and methods

### 2.1. Participants

The participants consisted of thirty healthy students from the university (Faculty of Medicine, Pharmacy and Dentistry). All were French native speakers. They were paid for their participation. They ranged in age from 19 to 29 years (mean: 22.6 years) and in weight from 49.6 to 85 kg (mean: 63 kg). They had no medical illness or history of alcoholism, drug abuse, or tobacco consumption of more than 10 cigarettes per day. There were no chronic benzodiazepines users, and no participants had taken concomitant medication for at least 15 days. The two groups did not significantly differ in age,  $t(28) = .07$ , ns; or weight,  $t(28) = .05$ , ns. They were pseudo-randomly assigned (on the basis of age, weight and general knowledge) to one of two parallel groups: a placebo group ( $n = 15$ ) and a lorazepam 0.038 mg/kg group ( $n = 15$ ) using a procedure which took account of their general knowledge as evaluated by the Information and Vocabulary subtests of the Wechsler Adult Intelligence Scale Revised (WAIS-R, Wechsler, 1987). The two groups did not differ significantly in their pre-drug general knowledge evaluated by the Information (13.1 for the placebo group and 12.8 for the lorazepam group),  $t(28) = .61$ , ns and Vocabulary subtests (12.3 and 12.7, respectively),  $t(28) = .87$ , ns. Informed written consent was obtained from all volunteers before they entered the study which was approved by the Faculty Ethics Committee. Participants were instructed to abstain from beverages containing caffeine and alcohol for the 24 h prior to the study. Smoking was not allowed on the day of the experiment.

### 2.2. Materials

The stimuli for the experiment consisted of 100 general knowledge questions. The correct answer was always a single word or a proper name. In the recognition task, the participants were offered five possible answers, including the correct one. Twenty unanswerable questions were also presented, most of them were taken from Schwartz et al. (2000) (e.g., *For which country is the jaque the monetary unit?*). These questions sounded plausible but did not have a correct answer (e.g., *There is no country with a monetary unit called the jaque*). Computerized versions of the task were used.

### 2.3. Procedure

The drug capsule was given orally to each participant at 7:30 a.m. using a double-blind procedure. The experimental session started 90 min after the intake of the drug at 9:00 a.m. Each participant was tested individually in the presence of an experimenter and the session lasted approximately 1–1.5 h. The participants were told that they would be asked to answer a series of general knowledge questions, some of which would be easy and some more difficult. The questions were presented one at a time on the computer screen.

The participants were given an explanation of what the term “tip-of-the-tongue” means. They were instructed not to confuse a strong feeling-of-knowing and a TOT. They were also informed that the TOT is a relatively rare phenomenon and that they might not experience any such phenomena during the course of the experiment. These instructions were provided in order to avoid the risk that task-demand characteristics might produce TOTs (Widner et al., 1996).

The participants were asked to give the answer aloud or to say “I don’t know” and the experimenter entered the answer at the keyboard. If a participant gave the correct response, the experimenter moved on to the next question. If the participants produced an incorrect answer then they were informed of this. If they indicated that they did not know the answer (omission errors) or if they provided an incorrect answer (commission errors), they were asked if they were in a TOT state and then they made a FOK judgment. A FOK judgment was defined as a prediction of successful recognition (Nelson, 1988). The participants were told that they would have to select the correct answer from a set of five answers. They judged the probability of them recognizing the correct answer on a scale consisting of six percentage values (0–20–40–60–80–100%). Finally, the participants completed a recognition test for these answerable questions.

At the end of the study (2 h and 30 min after consuming the capsule), the participants assessed their state on the basis of 16 visual analog scales (Norris, 1971). Each scale consisted of a 100-mm ungraduated horizontal line with definitions of contrasting states of mind at either end. The participants were asked to rate their feelings at the time of assessment by placing a vertical mark across each line to indicate their rating level. The mean score on nine of these scales (alert-drowsy, strong-feeble, muzzy-clear-headed, well coordinated-clumsy, lethargic-energetic, mentally slow-quick witted, attentive-dreamy, incompetent-proficient, and interested-bored) was taken as a measure of sedation (Bond & Lader, 1974). This procedure showed that, overall, sedation scores were higher for the lorazepam ( $S = 36.6$ ;  $SD = 14.1$ ) than for the placebo group ( $S = 23.8$ ;  $SD = 13.3$ ),  $t(28) = 2.5$ ,  $p < .05$ . Pearson correlations were also calculated between the sedation score and the memory and metamemory performances. No significant correlation was found between the self-ratings of sedation and recall performance and mean feeling-of-knowing, either in the lorazepam group or in the placebo group.

### 3. Results

#### 3.1. Recall and recognition performances

Table 1 presents the memory performances for the two groups of participants. In the recall task, the mean proportion of total answers (correct answers plus commission errors) did not differ significantly between the two groups  $t(28) = .2$ ,  $p = .86$ , ns. However, the proportion of correct answers was significantly lower in the lorazepam participants,  $t(28) = 2.3$ ,  $p < .05$ . Consequently, the lorazepam participants produced a higher proportion of commission errors than did the placebo participants  $t(28) = 2.3$ ,  $p < .05$ . The lorazepam participants did not produce significantly more answers (3.4) than the placebo participants (2.5) for the unanswerable or illusory questions  $t(28) = 1.2$ ,  $p = .26$ . The recognition test used a forced-choice format. The participants could choose the correct answer or a distractor. Choosing a distractor represented a commission error. There was no difference between the two groups in terms of correct answers and commission errors in the recognition test.

#### 3.2. Distribution of tip-of-the-tongue states across errors and groups (Table 2)

Omission TOTs are TOTs not preceded by an answer, while commission TOTs are TOTs that occur after the participant realizes that he or she has produced an incorrect answer. Seven of the thirty participants did

Table 1

Mean proportions of answers in the recall and recognition tests. (Standard Deviations in parentheses)

	Placebo	Lorazepam
Proportions of omissions	.245 (.08.5)	.239 (.099)
Proportions of recall answers	.755 (.083)	.761 (.099)
Correct answers	.787 (.092)	.696 (.122)
Commission errors	.213 (.092)	.304 (.122)
Recognition test		
Correct answers	.837 (.047)	.813 (.061)
Commission errors	.163 (.047)	.087 (.061)

Table 2  
Mean proportions of TOTs and n-TOTs for omission and commission answers

	Placebo	Lorazepam
Omission TOTs	.331 (.180)	.315 (.150)
Commission TOTs	.237 (.186)	.232 (.168)

not produce either of these types of TOT (three lorazepam and four placebo). Overall, the placebo participants reported 166 TOTs, 117 of them being omission TOTs and 49 of them commission TOTs. The lorazepam participants reported 184 TOTs, with 108 omission TOTs and 76 commission TOTs. The individual proportions of TOTs were similar in the two groups and there was no difference between the proportions of TOTs produced after an omission error  $t(27) = .26, p = .80$ , ns (respectively, .331 and .315). More surprisingly, there was no significant difference between the proportion of TOTs produced after a commission error in the placebo and lorazepam groups  $t(25) = .18, p = .86$ , ns (respectively, .237 and .232). It is likely that the participants with lorazepam exhibited a larger number of commission TOTs because they produced a greater number of commission errors. TOTs were significantly more common in the case of omission errors than after commission errors in the placebo participants  $t(13) = 2.35, p < .05$ . This was not observed for the lorazepam participants who provided only marginally more omission than commission TOTs  $t(12) = 2.0, p = .07$ . Thus, the lorazepam and the placebo participants experienced phenomenological TOTs at the same rate after commission errors which revealed retrieval failures.

### 3.3. Negative and illusory TOTs

Participants may suffer from two types of specific inaccurate TOTs: firstly when they feel a TOT for unanswerable questions (illusory TOT, Schwartz et al., 2000) and secondly when a phenomenological TOT is followed by incorrect recognition (negative TOT, Schwartz et al., 2000; Vigliocco et al., 1997). We compared the effect of lorazepam on these two types of specific TOTs. These occurred only rarely and no difference was observed under the effect of the amnesic drug (data not shown).

### 3.4. Correct recognition of TOT targets

We examined whether TOTs were accurate predictors of recognition and whether lorazepam had a specific effect on the efficiency of TOT recognition (see Table 3). Recognition should be higher after a TOT than after a n-TOT. In the placebo group, the recognition of TOT targets was significantly better than after n-TOTs,  $t(13) = 8.3, p < .01$ . In the lorazepam group, the correct recognition of the TOT targets was only marginally better than that of n-TOTs,  $t(13) = 2.1, p = .054$ . These data are also reflected in the  $\gamma$  correlations which will be discussed below. The difference in the ability to resolve TOTs between the placebo (83.1) and lorazepam (73.2) groups was not significant  $t(27) = 1.3, p = .19$ , ns.

### 3.5. Linguistic analysis of the commission TOTs

An analysis of the nature of the answers provided in the case of commission TOTs revealed that the errors were of the same type in the two groups, most of them being semantically related to the target (48 for the placebo and 72 for the lorazepam group). The proportion of commission TOTs that were semantically related to the target was not different in the placebo (.982) and the lorazepam (.951) groups,  $t(21) = 1.0, p = .33$ .

Table 3  
Mean proportions of correct recognition after a TOT or a n-TOT

	Placebo	Lorazepam
TOT	.831 (.106)	.732 (.262)
n-TOT	.593 (.056)	.594 (.113)

Table 4  
FOK estimations for TOT and n-TOT questions

	Placebo FOK	Lorazepam FOK
TOTs	75.6 (14.8)	68.1 (17.1)
n-TOTs	38.6 (17.4)	46.1 (18.7)

### 3.6. Feeling-of-knowing judgment (Table 4)

In the case of the answerable questions, the mean FOK judgments did not differ between the placebo and the lorazepam participants (50.2 and 51.7, respectively),  $t(28) = .26$ ,  $p = .80$ , ns. It should be noted, however, that because the control participants recalled more correct information, the FOKs were not made on an equivalent set of items. For the unanswerable questions, the mean FOK was significantly higher in the lorazepam (26.4) than in the placebo participants (15.2),  $t(28) = 2.8$ ,  $p < .01$ . We also wondered if TOT or n-TOT questions elicited different FOK ratings (Table 3). The mean FOKs were significantly higher after a TOT than after a n-TOT  $F(1,27) = 158.6$ ,  $MSE = 123000.3$ ,  $p < .0001$ . There was no difference between the placebo and lorazepam groups  $F(1,28) = .004$ ,  $MSE = 2.2$ ,  $p = .95$ . However, the TOT  $\times$  group interaction was significant  $F(1,27) = 11.5$ ,  $MSE = 894.1$ ,  $p < .01$ , and the difference in FOK ratings between the placebo and lorazepam groups was significant for TOT and n-TOT (for TOTs  $F(1,27) = 6.1$ ,  $MSE = 476.2$ ,  $p < .05$ ; n-TOTs,  $F(1,27) = 5.3$ ,  $MSE = 418.1$ ,  $p < .05$ ). To summarize, the main effect of lorazepam on FOK ratings was an overestimation for unanswerable questions and a loss of sensitivity in the relative rating of the future probability of recall of TOT and n-TOT responses.

### 3.7. $\gamma$ correlations

We computed three  $\gamma$  correlations. The  $\gamma$  correlations between TOTs and recognition in the placebo (.55) and the lorazepam participants (.37) were not significantly different,  $t(26) = 1.2$ , ns, thus indicating that the predictive accuracy of TOTs on recognition was preserved by the drug. These correlations were significantly different from zero and mean that the participants identified the correct answer in the recognition test more frequently when they said that they were in a TOT state. Similarly, the predictive value of FOKs on recognition was not impaired by lorazepam  $t(28) = .2$ , ns (respectively, .36 for the placebo and .35 for the lorazepam group). These correlations were very similar and were significantly different from zero. However, the predictive value of TOTs on FOK estimation was significantly higher in the placebo group (.86 against .67 in the lorazepam group),  $t(27) = 2.3$ ,  $p < .05$ . The lorazepam participants therefore suffered from an impairment of the relationship between the two forms of monitoring knowledge.

## 4. Discussion

The aim of this study was to investigate whether the larger number of incorrect recalls on general knowledge questions in lorazepam participants might be related to the fact that they experience more cognitive TOTs which become phenomenological TOTs only after the participant becomes aware of the retrieval failure. More commission TOTs were observed in the lorazepam participants, largely because these participants made more commission errors. The rate of commission TOTs did not increase in the lorazepam participants. We also tested our hypothesis that commission TOTs can be considered as real and robust cognitive and metacognitive entities, i.e., that the cognitive state of TOT (the failure of the process to retrieve a known word) and the phenomenological experience of TOTs (the strong feeling that a particular word is on the point to be retrieved) can be dissociated. In this regard, we found that commission TOTs did not substantially differ from omission TOTs (cf. Taylor & MacKay, 2003). Moreover, the cognitive TOTs observed under the effect of lorazepam were often not accompanied by phenomenological TOTs, at least until these were brought to the participant's attention, thus demonstrating a dissociation between cognitive and phenomenological TOTs (see Schwartz, 2002a). Finally, if TOTs reveal a conflict between the cognitive and the metacognitive levels, we suspected that the fact that lorazepam has anxiolytic and anticonflict effects could help us gain a better understanding of the

mechanisms and occurrences of commission TOTs. The data regarding this issue was unclear. Whereas lorazepam did not increase the rates of commission TOTs compared with placebos, we did find that lorazepam lowered the correlation between TOTs and FOKs.

Let us start by reviewing our results. In our re-analysis of the Bacon et al. (1998) experiment, it was necessary to reconfirm some of the conditions underlying the hypothesis that commission TOTs are real. Most of the commission errors produced under the effect of lorazepam tended to be based on a semantic relation to the actual target, and can thus be considered as plausible persistent alternates if made prior to a TOT. We also observed that some inferential abilities were preserved by the drug. This means that it is possible that the ability to correctly monitor the future retrievability of currently unavailable information is largely unimpaired by lorazepam.

In the present experiment, participants who were receiving lorazepam also provided the same number of total recall answers. However, the lorazepam participants produced more incorrect recall responses, i.e., commission errors, than the participants who were receiving the placebo. This lower semantic memory performance was not due to a difference in the basic knowledge of the two experimental groups, because their base rates, evaluated before drug intake, were similar. We also observed that recognition ability was preserved given that recognition performance did not differ between the two groups. Overall, the lorazepam group experienced a greater number of commission TOTs. However, the lorazepam participants did not produce higher individual rates of commission TOTs than the placebo participants. They experienced more commission TOTs because they made more commission errors. Moreover, the accuracy of these TOT states as predictors of recognition was equivalent.

#### *4.1. Increased rates of commission errors and occurrences of commission TOTs*

The increased rate of commission errors together with the preservation of the recognition ability suggests that lorazepam temporarily inhibits the retrieval of the correct response, thus creating cognitive TOTs. Lorazepam either slows down the process or results in cognitive disinhibition which leads to the increased accessibility of close neighbors that cannot be readily dissociated from the target. This process would contribute to the production of the persistent alternates. It is after these commission errors are identified as such that the phenomenological TOT state is aligned with the cognitive TOT state. Similarly, participants receiving lorazepam provided more answers to illusory questions, a fact which also suggests that there is an impairment in semantic information processing. We suggest that the impaired recall performance of the lorazepam participants could be partly the result of a dissociation between the phenomenology and the cognitive process of a TOT state: the participant experiences temporary retrieval failure (i.e., the cognitive state of a TOT), but is not aware that the retrieved answer is incorrect and does not therefore experience the phenomenological TOT. Lorazepam creates the conditions under which persistent alternates come to the mind more easily. Because a phenomenological TOT does not occur alongside the retrieval failure, the persistent alternates are output as answers and end up being scored as commission errors. This hypothesis appears to be confirmed since, overall, the lorazepam participants committed more commission errors.

We hypothesized that the commission errors made by participants when in a cognitive TOT should be equivalent to the persistent alternates of the spontaneous TOTs. Participants may not recognize the persistent alternate as such and this situation would then lead them, in good faith, to provide the persistent alternate as a suitable target answer. This means that the commission error produced in a cognitive TOT should share the properties of the spontaneous persistent alternates. Indeed, most of the errors that were followed by a phenomenological TOT were semantically related to the target answer, similar to what has been observed in the case of TOTs following omission errors (Harley & Bown, 1998; also see Burke et al., 1991; Reason & Lucas, 1984). Furthermore, most of the cognitive and metacognitive properties of the TOTs were preserved by lorazepam (resolution abilities of TOTs, predictive accuracies of FOK and TOT, occurrence of illusory and negative TOTs, etc.). Such observations imply that the cognitive impairment must occur prior to the effect of lorazepam on the TOT phenomenology, as lorazepam does not seem to have any effect on the omission errors or the omission TOTs.

#### 4.2. *Why does the phenomenology of TOTs occur after commissions at all?*

We observed that lorazepam-treated participants sometimes experienced TOT phenomenology after commission errors. This was expected as we had previously observed that, under certain circumstances, lorazepam-treated participants are able to experience TOT phenomenology (unpublished data from Massin-Krauss et al., 2002). Moreover, in the present study, the participants who were receiving lorazepam experienced the same amount of omission TOT as the placebo participants. This was also expected, because if the omission TOTs had turned into commission TOTs under the effect of the drug, then the drugged participants should have provided more recall answers than the placebo participants and this was not the case either in this study or in previous studies involving general knowledge questions (Bacon et al., 1998; Massin-Krauss et al., 2002). Instead, it was the items that might have been recalled correctly under normal circumstances that became commission TOTs under the effect of lorazepam.

The current experiment provides us with some clues concerning the question of why TOT phenomenology occurs after commissions at all, a question which is of fundamental importance if we are to gain a better understanding of normal cognitive processes and failures. The literature reveals that semantic memory, as evaluated in tests of verbal fluency, is not modified by the effect of benzodiazepines (Curran, 1991; File et al., 1992; Fluck et al., 1998; Vermeeren et al., 1995), thus suggesting that the global accessibility of the semantic store remains largely unaffected by lorazepam. The results presented here could reconcile our observations of an impairment of semantic memory in general knowledge tasks with the preserved performances of lorazepam-treated participants in verbal fluency tasks. Some of the authors who have used fluency tasks have also observed a slowing down of reaction times (Brown, Brown, & Bowes, 1983; Green et al., 1996; Vermeeren et al., 1995). In verbal fluency tasks, the slowing down of the normal retrieval process induced by the drug does not affect its accuracy. However, this is not the case for general knowledge questions which require the retrieval of a single correct answer. Cognitive TOTs are usually considered to represent a slowing of the normal recovery phenomenon (e.g., Brown, 1991) and these TOTs seem to occur more frequently in response to lorazepam administration. The great diversity of the errors made also suggests that the lorazepam participants fail to progress beyond a preliminary stage in the lexical search (e.g., Miozzo & Caramazza, 1997). As the errors are mostly semantically related to the target, the preserved accessibility to the semantic store would allow the retrieval process to return items belonging to the correct general category, but not necessarily the single correct answer corresponding to the specific question. Thus, the slowing down of the response allows persistent alternates to be retrieved as well as the correct answer. This can lead to the output of an incorrect answer, followed by a phenomenological TOT when the incorrect nature of the answer is revealed.

Let us turn now to the monitoring aspects of the commission TOTs. The monitoring failure in commission TOTs concerns the inability to detect the temporary inaccessibility of the correct target. Koriat (1998) argued that “the key to the illusion of knowing must lie not only in the inaccessibility of the correct target, but also in the inflated accessibility of contaminating clues that cannot be readily discredited (p. 27)”. In line with this hypothesis, the error involved in not spontaneously experiencing TOT phenomenology in the case of commission TOTs could also consist of an exaggerated retrospective confidence in the persistent alternate. However, once the commission error has been revealed, the great amount of related information accessed may induce individuals to experience a TOT. Indeed, Schwartz and Smith (1997) observed that participants use the products of the retrieval process as a source of information for phenomenological TOT states. This would seem to provide a clearer explanation of the appearance of TOT phenomenology after the participant has been told that his/her response is incorrect.

#### 4.3. *Why do lorazepam participants not experience TOTs when they retrieve persistent alternates?*

In commission TOTs, the phenomenology, i.e., the anxiety and the conflict, is not felt by the participant. Indeed, lorazepam is an anxiolytic drug that has well-known anticonflict effects and alleviates emotions (Harvey, 1980; Kleven & Koek, 1999; Vanover et al., 1999). It is worth asking whether it is the anxiolytic effect of lorazepam that eliminates the conflict, thus resulting in a dissociation between the phenomenology and the cognitive component of TOTs. Individuals under the effect of lorazepam would more often not be conscious of the emotional conflict between the persistent alternate and the missing correct answer. They would there-

fore be more likely to produce the persistent alternate more frequently. However, when they are told that they are wrong, the retrieval failure state becomes identifiable and triggers a normal phenomenological TOT. Thus, in a certain sense, lorazepam seems to mask the emotional state created by the TOT conflict with the result that more commission errors are committed and more subsequent TOTs occur when the conflict becomes apparent. No consciousness of the conflict emerges because lorazepam dampens the emotions associated with this conflict.

The effect of lorazepam on semantic retrieval and on the emotional regulation of TOTs seems to follow a sequential model. This model implies that lorazepam first modifies the semantic processes with a slowing down of the cognitive process, thus resulting in more cognitive TOTs coupled with the retrieval of persistent alternates (Smith, 1994). Secondary to this, the anxiolytic effect of lorazepam would influence the emotional aspect of the TOT and suppress the phenomenology which might ordinarily alert the participant to the conflict. The result of this would be an increased number of commission TOTs. In such a model, the ultimate effect of lorazepam on semantic memory (the production of errors because the anxiolytic effect of the drug has suppressed the emotional conflict associated with the TOT) would be secondary to the cognitive effect of the drug (slowing down of the normal retrieval process). This may occur because lorazepam suppresses the psychological discomfort and anxiety associated with the normal occurrence of a phenomenological TOT. The fact that an earlier experiment showed that general inferential abilities are preserved and that FOK estimations are not strikingly different in lorazepam-treated and placebo-treated participants seems to suggest that it is not the monitoring abilities, but instead this emotional component, that is affected by amnesic drug.

To summarize, the amnesic drug lorazepam increased the number of retrieval failures. However, these cognitive errors were accompanied by an increase in TOT phenomenology which was only observed after the participants had been informed of their recall error. Lorazepam-treated participants exhibited more commission TOTs because they committed more commission errors. Cognitive TOTs following commission errors seem to be genuine, plausible entities corresponding to a particular cognitive and metacognitive state. The anxiolytic and anticonflict effect of benzodiazepines seems to contribute to the increased occurrence of these specific memory blockages. The emergence of TOT phenomenology seems to be necessary if participants are to resolve the blockage created by persistent alternates adequately. The use of lorazepam allowed us to gain a better understanding of the mechanisms that may be responsible for the TOT experience. Many of our arguments are somewhat speculative and require further investigation. However, under experimental conditions, we observed an increase in the number of persistent alternates while keeping the level of correct recognition constant. This approach could provide a useful tool for psychologists and linguists who wish to study the effect of persistent alternates on the TOT process.

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