Chapter 5
Further Insight into Cognitive and Metacognitive Processes of the Tip-of-the-Tongue State with an Amnesic Drug as Cognitive Tool

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When I remember forgetfulness there are present both memory and forgetfulness, memory, whereby I remember, forgetfulness, which I remember. Then is forgetfulness retained by Memory.

[St Augustine, Confessions]

1 Introduction

Everybody has probably experienced at least once in their life the frustration of being unable to retrieve a particular word at the desired time. To have the word on the *tip of the tongue* (TOT) is a very common oblivion, but it also reveals the awareness we have of the content of our own memory. States such as TOT may be viewed as transient and reversible micro-amnesia commonly affecting healthy people. Might it be possible to use amnesic drugs (e.g., lorazepam) to decipher this phenomenon? As in a TOT state, individuals under lorazepam would momentarily have no access to a known piece of information but would retrieve a word closely related to the target answer and provide it as the response to the question. Moreover, unlike normal people, who are well aware that this information that comes to mind is *not* the correct answer and have a strong sense of having the correct word on the tip of their tongue, we hypothesised that under the effect of lorazepam there would be a dissociation between the cognitive and metacognitive components of the TOT experience, and that lorazepam-treated participants would inappropriately attribute a high confidence rating to the intrusive incorrect word. In this chapter, we present why we were prompted to suggest the TOT model as an explanation for the peculiar pattern of temporary semantic memory/metamemory impairment induced by the amnesic drug lorazepam and we describe in detail how we experimentally verified this hypothesis (Bacon, Schwartz, Paire-Ficout, & Izaute, 2007).

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1.1 Drugs as Tools for Exploring Memory Functioning

Our current knowledge about cognitive processes and functions stems from research performed with different populations (Danion, 1994). The more conventional studies involve healthy participants and highlight fundamental notions common to all. Other studies recruit individuals suffering from traumatic or organic memory pathologies, such as Alzheimer's disease. However, the study of clinical populations is likely to be problematic because the nature and extent of the brain lesion may vary from one individual to the next, and patients may be suffering from additional pathologies or taking drugs that may complicate interpretation of the observations.

A growing number of studies have been conducted originating from a theoretical viewpoint, but involving the administration to healthy participants of amnesic drugs viewed as tools for revealing functional principles of normal cognitive processing. Drugs from the benzodiazepine family were first described as having an amnesic effect in 1965 and are now widely used as tools for the purpose of memory studies (Duka, Curran, Rusted, & Weingartner, 1996). Their amnesic effect, particularly on episodic memory, is well known. The amnesic episode induced by benzodiazepines is transitory, lasting only for a few hours. In the case of episodic memory, healthy participants administered a benzodiazepine experience anterograde amnesia, and it is the acquisition of new information that is impaired by the drug (for review see Beracochea, 2006; Curran, 1999). Lorazepam is particularly interesting as a benzodiazepine, because it has no active metabolites. During the amnesic episode, participants are not aware of their memory deficit, and lorazepam has also been shown to induce some metamemory impairments (Bacon et al., 1998; Izaute & Bacon, 2005).

1.2 Effects of the Amnesic Drug Lorazepam on Semantic Memory

Very few drugs have been shown to alter semantic memory. It has long been taken for granted that benzodiazepines do not alter semantic memory (Curran, 1991, 1999). These conclusions relied mostly on unimpaired performance in verbal fluency tasks, where participants were required to provide as many items as possible from a given semantic category within a set time (Curran, 1991; File, Sharma, & Shaffer, 1992; Fluck, File, Springett, Kopelman, Rees, & Orgill, 1998; Vermeeren et al., 1995). However, findings with sentence verification tasks were found to be contradictory. Allen, Curran, and Lader (1993) and Green, McElholm, and King (1996) found that lorazepam did not affect the accuracy of semantic retrieval, whereas Vermeeren et al. (1995) reported that lorazepam-treated participants made more mistakes in these tasks than placebo participants. In addition, File et al. (1992)

showed that the benzodiazepine midazolam impaired word completion performance, and they observed that participants under benzodiazepine generated more low frequency exemplars than common words when retrieving categorical information from memory, which could be due to the fact that the most common, high frequency answers were temporarily not accessible and that the participant had to recruit more uncommon words from his or her semantic store to complete the task.

Some researchers observed (Bacon et al., 1998) and replicated (Izaute, Paire-Ficout, & Bacon, 2004; Massin-Krauss, Bacon, & Danion, 2002) an impairment in semantic memory, when healthy participants were under the effect of the benzodiazepine lorazepam. In these studies, participants were presented with general knowledge questions (e.g., What is the capital of Greece?) and had to recall the answer (e.g., Athens). Those under the effect of lorazepam produced as many recall answers as the participants under placebo, but gave more incorrect answers (commission errors) (see Table 5.1).

The impairment that lorazepam induces in semantic memory is reversible. Benzodiazepines are the most commonly consumed drugs in the western world because of their effects on anxiety, insomnia and muscle relaxation, and if the semantic impairment was permanent, clinical and daylife observations would have been noticed. However, to confirm the reversibility of the amnesic effect on semantic memory, 2 years after the experiment of Bacon et al. (1998), three participants who had taken lorazepam and one who had taken the placebo were retested in their usual or sober state. The transitory nature of the amnesic episode was confirmed as the performance of the ex-lorazepam participants improved (see Sect. 5.1), whereas that of the ex-placebo participant was similar to his performance 2 years earlier. Furthermore, lorazepam participants were more likely to experience a common

Table 5.1 Means (and *SD*) of performance on free recall and recognition tasks and of confidence level accuracy in the placebo and lorazepam groups (adapted from Bacon et al., 1998) and gamma correlations

	Group	
	Placebo	Lorazepam
	M (*SD*)	*M* (*SD*)
Free recall task		
Proportion of answers	61 (14)	57 (16)
Proportion of correct answers	82 (8)	60 (12)*
Recognition task		
Proportion of correct answers	58 (9)	49 (12)
Confidence level accuracy	82 (11)	80 (9)
For correct answers	87 (8)	88 (7)
For incorrect answers	57 (14)	68 (12)**
Gamma correlation		
Between confidence level accuracy and recall performance	0.65	0.61

*Significant difference at $p<0.05$

**Marginally significant difference at $p=0.07$

semantic illusion, the "Moses Illusion"[1] (Erickson & Mattson, 1981; Reder & Kusbit 1991). They also provided more incorrect recalls for the filler questions in the Moses paradigm, and this observation is an additional argument in favor of the existence of an impairment of semantic memory induced by lorazepam (Izaute et al., 2004).

It must also be borne in mind that the pattern of cognitive impairment induced by benzodiazepines may vary from one molecule to the next (Giersch, Boucart, Elliott, & Vidailhet, 2010). Mintzer, Kleykamp, and Griffiths (2010) observed that another benzodiazepine, triazolam, had no effect on performance in a general information task. The pattern of semantic memory impairment induced by lorazepam also differs from that induced by another potentially amnesic drug, ethanol. In a general information task, healthy participants under the effect of ethanol produced fewer recall answers compared to placebo participants (Nelson, McSpadden, Fromme, & Marlatt, 1986), whereas under lorazepam participants provide the same number of recall answers, but with a higher error rate.

1.3 The Peculiar Pattern of Memory/Metamemory Impairment Induced by Lorazepam for Semantic Memory

In their study, Bacon et al. (1998; see Table 5.1) used the classic recall-judgment-recognition paradigm (Hart, 1965). Participants were 12 placebo and 12 lorazepam (0.038 mg/kg) indivilduals. They were presented with 120 general knowledge questions and asked to recall the answers. For each answer they provided, they had to rate their retrospective confidence level that the answer given was correct. The lorazepam-treated participants seemed to selectively overestimate their retrospective confidence level for incorrect recalls, which was marginally higher than that of the placebo particpants, $t(22) = -1.91$, $p = 0.07$. However, the treated participants were still able to discriminate between correct and incorrect answers, as their confidence was higher for correct than for incorrect answers, and their gamma correlations between confidence levels and free recall performances were no different from those of the participants who had received a placebo. Thus, the drug seemed to induce a selective impairment of their monitoring ability. The same pattern of a higher rate of incorrect recall coupled with an overestimated confidence level for incorrect recalls ($p < 0.001$) and preserved monitoring accuracy was also observed in the context of a forced-recall task with respect to general knowledge questions (Massin-Krauss et al., 2002).

Evidence of impaired recall performance in a general knowledge task suggests that the control process might be impaired too. The drug might have altered the way participants make decisions and may have induced a desinhibitory state leading

[1]The Moses illusion is as follows: When asked "How many animals of each kind did Moses take on the ark?" people fail to notice the distortion introduced by the impostor "Moses" and respond "two". This semantic illusion, which is known as the Moses illusion, has proved to be quite robust and can be generalized across other materials and conditions.

them to output answers they might otherwise keep to themselves. In that case, one would expect lorazepam participants to provide more recall answers than placebos in a free recall task. However, the number of answers produced by the lorazepam participants was no different to the number provided by the placebos (Bacon et al., 1998), casting some doubt on this view. Furthermore, the effects of lorazepam on the processes involved in the strategic regulation of memory accuracy (Koriat & Goldsmith, 1996) have been investigated (Massin-Krauss et al., 2002). Control sensitivity, that is, the extent to which volunteering an answer is affected by confidence judgments, was only slightly impaired by the drug. Consequently, defective control sensitivity cannot explain all the extra commission errors produced under the effect of lorazepam in a semantic task.

Within the context of a reversible semantic memory impairment and relative preservation of decision-making, it is possible to re-phrase the question of why lorazepam participants provide an incorrect recall when they actually know the right answer, that is, under what circumstances is the memory of healthy participants temporarily impaired to such an extent that they are prompted to give an incorrect answer when they actually know the correct answer? There are everyday situations where individuals do behave in this manner, that is, when they are in a TOT state. Specifically, when a person is experiencing a TOT state, she or he cannot retrieve a known piece of information, and sometimes the TOT state is accompanied by an intrusive incorrect blocking word.

2 The TOT State

In everyday life we may all experience ordinary memory defects (Schacter, 1999), that may be either permanent or transient. The blank-in-the-mind (BIM) experience is a very common memory failure (see Efklides & Touroutoglou, Chapter 6). One of the most spectacular transitory memory impairments is probably the TOT state. The TOT state may occur for both semantic and episodic memory (Schwartz 1998; Schwartz, Travis, Castro, & Smith, 2000). When a person is experiencing a TOT state, she or he cannot retrieve a known piece of information. At the same time, the person has the strong and frustrating feeling that the missing target word is on the verge of being retrieved (Schwartz, 2002a, b). Schwartz (1999) wondered whether this experience is really universal and whether the "tongue" metaphor is used in other languages too to describe this peculiar state. He observed that, out of 51 languages, as many as 45 employed an expression using the "tongue" metaphor to describe this feeling of not being able to retrieve a known word. Brennen, Vikan, and Dybdahl (2007) observed that speakers of an unwritten Guatemalan language were able to recognize a description of the phenomenology associated with tip-of-the-tongue states and that TOT states could also be induced in this particular group of participants.

A TOT state is a relatively stressful and emotional situation often coupled with a feeling of frustration. The TOT state is a transitory state of inaccessibility of a known piece of information and accurate predictor of later recall and recognition (Schwartz,

2002b), that is, when rememberers experience TOT states, they are likely to retrieve the correct answer eventually, since 89–95% of the missing words are subsequently retrieved (Burke, MacKay, Worthley, & Wade, 1991; Schwartz, 2002a; Schwartz et al., 2000; for reviews see also Brown, 1991; Schwartz, 2002b).

Diary studies and laboratory tasks also show that 50–70% of TOT states are accompanied by intrusive blocking words, also known as "interlopers", or persistent alternates (Burke et al., 1991; Reason & Lucas, 1984). For example, in diary studies, Reason and Lucas (1984) found that over 50–70% of the resolved TOT states were preceeded by intrusive blocking words. Burke et al. (1991) observed that in a sample of young adults 67% of the TOT states were accompanied by what they called "persistent alternates" – the term we will use throughout this chapter. Furthermore, Burke et al. (1991) found that nearly 90% of the persistent alternates were from the same syntactic category as the missing world. These alternates were recognized as incorrect by the participants, who, however, were unable to retrieve the correct target in the meantime. Laboratory studies show higher rates of both resolution and persistent alternates among TOT states than among non-TOT states (Smith, 1994). Recognition of the correct target following a TOT state is much more likely than recognition of the correct target when rememberers are not experiencing a TOT (Schwartz, 1998, 2001; Schwartz et al., 2000; Schwartz & Smith, 1997; Smith, 1994).

The phenomena underlying TOT experiences are at the intersection between memory, language, and metamemory models and have been the subject of numerous studies by researchers from various disciplines (Schwartz, 1999, 2001). For psycholinguists and memory theorists, the TOT state and word retrieval are triggered by the same retrieval process. TOT states are interesting because they serve as "windows" to the retrieval process (Biedermann, Ruh, Nickels, & Coltheart, 2008; Brown, 1991). The metacognitive view is that TOT state and retrieval process are dissociable (Schwartz, 2001). The TOT state is classifiable as a *metacognitive judgment*, whereas retrieval is a *cognitive process*.

3 TOT as a Cognitive and Metacognitive Experience

We shall focus here on the metamemory perspective regarding the TOT state. Schwartz et al. (2000) used Nelson and Narens' (1994) model to explain the TOT state. Object-level cognition (encoding, imaging, retrieving…) is separate from meta-level cognition (feeling of knowing or judgment of learning). Monitoring is the flow of information from the object-level to the meta-level, and control is the flow of information from the meta-level to the object-level. The TOT state plays a monitoring role by informing rememberers when an item may be retrievable. It may serve to alert the rememberers that more time may be needed to retrieve an item and to warn them not to terminate the search. Thus, it provides rememberers with useful information that can then be used to control mnemonic behaviour. The TOT state differs from a strong feeling-of-knowing judgment, because different brain areas are activated during TOT states and feeling-of-knowing judgments (Maril, Simon, Weaver, & Schacter

2005). Moreover, by manipulating working memory load during retrieval of general knowledge questions, Schwartz (2008) obtained data supporting the view that a TOT state and a feeling-of-knowing judgment are separable metacognitive entities.

We shall distinguish between two aspects of the TOT experience. Firstly, the cognitive state of TOT is defined as the failure of the retrieval process to produce a known word (Burke et al., 1991; Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997). This cognitive process is about word retrieval and the failure of that process. On the other hand, the phenomenological experience of a TOT state will be defined as the strong and frustrating feeling that a particular target word is on the verge of being retrieved (Brown & McNeill, 1966; Schwartz et al., 2000). This experience is a metacognitive one, as it involves a feeling of future memorability.

From a study of the literature, it would appear that the research conducted to date may support such a distinction between cognitive and phenomenological TOT states (Schwartz, 2002b). Research suggests that not all temporary retrieval failures are accompanied by a TOT state and that not all phenomenological TOT states are accompanied by the eventual retrieval of a target (Schwartz, 1998; Schwartz et al., 2000). Furthermore, research has demonstrated dissociations between retrieval and the number of TOT states (Schwartz & Smith, 1997; Widner, Smith, & Graziano, 1996). Throughout this chapter, we use the term "cognitive TOT" to refer to the temporary amnesia associated with a known word retrieval failure and the term "phenomenological TOT" to refer to the subjective experience of feeling that a word is retrievable.

A TOT state reveals a conflict between the metacognitive judgement, that is, the certainty that the information is known, and the cognitive level, that is, the temporary inability to retrieve a known target from long-term memory. The TOT state is regarded as the slowing down of a memory process and may be viewed as momentary and reversible "micro-amnesia" occurring naturally and occasionally in healthy people.

To summarize, TOT states appear to be very common in everyday life, are quite similar across language groups, and easy to induce in laboratory. Participants in a TOT state are momentarily unable to retrieve a known piece of information and may sometimes provide an incorrect answer, referred to as a "persistent alternate". And this is exactly what we hypothesized that has happened in participants under the effect of lorazepam with some items in a general knowledge task.

4 The Amnesic Effect of Lorazepam on Semantic Memory and TOT State

4.1 Similarities and Divergences Between Lorazepam-Induced Amnesic Episode and Naturally Experienced TOT

Under the effect of lorazepam, as well as when naturally experiencing TOT, healthy participants are temporarily unable to retrieve some known information

and sometimes retrieve information closely related to the target answer. There are striking differences, however, between what occurs in individuals experiencing TOT in everyday life and what occurs in participants under the effect of the benzodiazepine. First, when in a TOT state, and if a persistent alternate comes to mind, healthy individuals in an undrugged TOT state recognize this information as not being the correct answer. They have the feeling that the persistent alternate impedes their access to the correct answer, and they also feel very strongly that they know the target answer, and that retrieval of the target is imminent. Under lorazepam, however, participants do not recognize the incorrect item that comes to mind as being incorrect and so seem not to have the phenomenological experience of recognizing the incorrect item as a persistent alternate. They do not experience the phenomenological TOT. Second, the effect of lorazepam on participants increases the likelihood that they will give an incorrect answer despite knowing the correct response, thereby making a commission error.

We wondered then whether individuals under the effect of lorazepam could sometimes experience a kind of "dissociated" TOT. Specifically, they would experience the cognitive TOT (i.e., the correct target would be momentarily inaccessible and a persistent alternate would come to mind) but they would not reject the persistent alternate as such and would provide it as the target answer without recognizing the blocker nature of this response; in the meantime they would not spontaneously experience the phenomenological TOT, that is, the feeling that the correct answer is on the verge of being retrieved. We suggest that monitoring would be impaired, in that participants would not experience the TOT phenomenology, but that monitoring effectiveness (the ability to distinguish between correct and incorrect answers) would be preserved, insofar as the participants are still able to recognize the correct answer among distractors. Lorazepam would impair control at the point in time when they have to provide an answer (selection of the correct target in the recall step). This dissociation between monitoring and control has already been observed in the strategic regulation of memory accuracy under the effect of lorazepam (Massin-Krauss et al., 2002). Moreover, various patterns of memory and metamemory dysfunctioning have been reported in patients with brain lesions (Bäckman & Lipinska, 1993; Janowsky, Shimamura, & Squire, 1989a, b; Nelson et al., 1986; Pappas et al., 1992; Shimamura 1994; Shimamura & Squire, 1986, 1988). They suggest that memory and metamemory are not inextricably linked. The possible dissociation of the cognitive and the phenomenological TOT has already been evoked in the literature, that is, experience of the phenomenological TOT without its subsequent resolution has been referred to as "subjective TOT" by Jones and Longford (1987) or "negative TOT" by Vigliocco et al. (1997). On the other hand, commission errors followed only later by the phenomenological TOT were referred to as "commission TOT" by Schwartz et al. (2000). This is what we suspect occurs under the effect of lorazepam. We hypothesized that the incorrect recall answers provided by participants having experienced a commission TOT are the "blockers" or "persistent alternates" often retrieved by participants experiencing a natural TOT state.

A TOT experience is also a relatively stressful feeling, often accompanied by a sense of frustration, and has been shown to have an emotional dimension, that is,

the "phenomenal TOT" (Schwartz et al., 2000). Benzodiazepines act as anxiolytic drugs and have anti-conflict effects (Harvey, 1980; Kleven & Koek, 1999; Vanover, Robledo, Huber, & Carter, 1999). Consequently they may have an effect that attenuates the stressful, phenomenal aspect of the cognitive conflict elicited by a TOT state. As a result, we suggest that drugged participants would honestly provide the persistent alternate as a convenient answer to the question asked and would not feel that they were on the verge of recognizing the correct answer. According to this interpretation lorazepam should reduce the phenomenological TOT experiences (Massin-Kraus et al., 2002) while at the same time increasing the number of retrieval failures, as a result of incorrect reporting of persistent alternates.

To confirm this hypothesis, we investigated the effects of lorazepam on TOT states by using the drug as a pharmacological tool that should allow us to gain some insight into this phenomenon. We wanted to show that, in some cases, the phenomenological TOT does not occur until after participants have found out that their retrieval was inaccurate. Thus, we shall argue in favour of a TOT model that distinguishes between cognitive and metacognitive (phenomenological) aspects of the TOT process (for a different view, see Taylor & MacKay, 2003).

4.2 Evidence for the TOT Model

Before exploring experimentally the effects of lorazepam on TOT states, we analysed unpublished data from Bacon et al. (1998) and Massin-Krauss et al. (2002) to examine a number of memory and metamemory features that might consitute additional cues in support of our hypothesis about the effects of lorazepam on TOT states.

First, we observed that lorazepam participants are able to experience the phenomenology of TOT in some error trials (data from Massin-Krauss et al., 2002), but to a lesser extent than the placebo participants. In that particular experiment, in the stressful situation of forced report recall of semantic memory, participants under lorazepam (0.038 mg/kg) reported an average of 2.3 TOT states (out of a total of 120 questions), which was a significantly lower rate of TOT states than that of the placebo participants ($M=4.9$, $p=0.037$). This observation lends weight to the hypothesis that the anxiolytic effect of lorazepam might have an effect on the number of TOT states reported.

Another of our aims was to determine whether the incorrect recalls provided by the participants under lorazepam were similar to the persistent alternates found in TOT studies. To that end, we examined the nature of the incorrect recalls provided by the participants in the Bacon et al. (1998) study. The drug had no effect on the mean number of recall answers given, but increased the number of incorrect answers. The commission errors were analyzed for the lorazepam 0.038 mg/kg group according to four criteria: (a) semantic substitution (oenologist instead of wine waiter); (b) phonological or semantico-phonological substitution, for example, *faines* (beechnuts) instead of *fanons* (whalebones); (c) perseverative errors (the answer was a word used in the question); and (d) commission errors with no

apparent link or invented words. The majority of errors were semantic, with 237 in the lorazepam group and 118 in the placebo group**.** The proportion of semantic errors was 76% for the lorazepam participants and 80% for the placebo participants. This difference was not statistically significant, $t(22) = 1.3$, $p = 0.19$. Phonological substitution counted for only 4% of the errors for lorazepam and 6% for the placebos, with no significant difference as a function of the treatment, $t(22) = 1.4$, $p = 0.18$. Perseverative error scores differed as function of the treatment for the commission errors. Specifically, participants under lorazepam had a higher perseverative error score (16%) than placebo-treated participants (9%), $t(22) = 2.8$, $p < 0.02$. Finally, there were some errors that were without any apparent link. Lorazepam-treated participants made no more errors in this category than placebos (4 and 5%, respectively), $t(22) = 0.9$, $p = 0.40$, and the overall rate was very low. So, taken as a whole, these results show that participants under lorazepam make commission errors similar to the persistent alternates observed in the TOT literature (Burke et al., 1991; Harley & Bown, 1998).

Also, in an item-by-item analysis, the total number of questions (out of the 120 questions asked) that produced at least one incorrect recall answer was higher in the lorazepam group than in the placebo group: taken together, the 12 participants in the lorazepam (0.038 mg/kg) group made commission errors out of a set of 105 questions and gave 235 different wrong answers to this set of questions, whereas the 12 placebo participants gave only 106 different wrong answers to 67 questions taken from the entire set of 120 questions they were asked to answer. So more questions were likely to elicit recall errors from lorazepam participants, and the range of possible incorrect answers was more diverse. This shows that under lorazepam the questions lead to the retrieval of information relevant to the target (Koriat, 1995), and that lorazepam participants do not inhibit incorrect answers as and when they are retrieved. It must be borne in mind, however, that the individual number of recall answers given by each participant did not vary with the lorazepam intake. Consequently, lorazepam may exert a cognitive disinhibition, prompting participants sometimes to provide an incorrect rather than correct answer, but not a behavioral disinhibition, which would have caused all of them to provide more recall answers than the placebo participants. The observation that participants under the effect of lorazepam are also more sensitive to the Moses effect and more often make partial matching also argues in favour of an impaired semantic treatment of the question (Izaute et al., 2004).

Finally, we explored the possibility that the overestimation in confidence judgments of incorrect recalls observed in lorazepam participants was a kind of "ghost memory", similar to what happens to people who have lost an arm and still have sensations in the missing arm (i.e., the phantom limb syndrome; see Flor, 2002; Melzack, Coderre, Katz, & Vaccarino, 2001). If that were the case, confidence judgments would be based on information about the permanent, usual, and undrugged state of participants rather than their current drugged state. Thus, a high confidence judgment may be considered to concord with the usual permanent state of the participant (knowing the answer), but unadapted to his/her actual temporarily amnesic state. To explore this possibility, three participants from the Bacon et al. (1998) study

who had received lorazepam were re-tested in their "natural" state 2 years later, together with one placebo participant. We compared their performance, as well as the accuracy of the judgments predicting their performance. From the drugged state to the normal state, the proportion of incorrect recalls dropped by more than 10% for the three participants who had first taken the lorazepam (respectively from 28 to 17%; 36 to 24% and 42 to 26%). The performance of the participant who had received a placebo for the first examination remained relatively stable across time (respectively 11 and 9% incorrect recalls). However, the mean confidence levels elicited by the participants who had previously been under the effect of lorazepam were in the range of 75–92 and varied by only six points (on a scale of 100) between the two test phases. The mean confidence levels of the placebo participant varied across a similar range (from 93 to 84) from the first to the second trial. The small sample presented here merely provides a few clues about the cognitive and metacognitive processes at work, but the fact that the memory performance of the three lorazepam participants was better when they were re-tested in an undrugged state, whereas that of the placebo participant was unchanged, seems to confirm that semantic memory is genuinely impaired by lorazepam. However, the confidence levels attributed to the recall answers by all the four participants remained relatively constant when tested either under lorazepam or under placebo.

What occurred with semantic knowledge under the effect of lorazepam may have been similar to the pain felt with the Phantom limb syndrome, "where the perception of pain does not simply involve a moment-to-moment analysis of afferent noxious input, but rather involves a dynamic process that is influenced by the effects of past experiences. Sensory stimuli act on neural systems that have been modified by past inputs, and the behavioral output is significantly influenced by the 'memory' of these prior events." (Melzack et al., 2001, p. 157). Participants under lorazepam could have been "influenced by the effects of past experiences", when they had easy access to the presently missing item. Consequently, they could have attributed to the transitory incorrect recall the same high confidence that they would usually have attributed to the correct answer that is momentarily not available because of the effect of the drug. Their behavioral output when rating their confidence would still rely on past inputs and their "memory of prior events", and this in turn would explain why their confidence levels under the drug or the placebo were the same. This lends support to the general idea of ghost memories; participants were basing their judgments on how their memory usually worked, not how it works under lorazepam. However, the present observation confirms the temporary nature of this retrograde impairment of semantic memory, as the ex-lorazepam participants performed better once the drug had been eliminated from their body, whereas the placebo participants' performance remained stable across time.

To summarize the additional analyses of previous experiments, the temporary impairment of semantic memory induced by lorazepam was confirmed in a general knowledge task, as was the preserved general access to knowledge about the topic of each question. Moreover, when under the effect of lorazepam, participants made commission errors that were semantically related to the target and more perseverative errors than the placebo participants.

4.3 The TOT Model as an Explanation for the Lorazepam-Induced Impairment of Semantic Memory

Of particular interest as regards the TOT model is that stating that an unrecalled target is on the tip of one's tongue implies at the very least that the target is known, and that recall is eminent to occur very soon.

In the next experiment, we investigated the possibility that participants under lorazepam could, for some items, be in a state of retrieval failure (i.e., temporary inaccessibility of a known item) and could retrieve a persistent alternate. However, they may not spontaneously experience phenomenological TOT, which would have told them that the correct target is a different word, on the verge of being retrieved. The persistent alternate would be given as the correct answer and attributed the same high degree of confidence they would usually attribute to the correct and otherwise known item. On being informed, however, that their response alternate is not correct, the lorazepam participants might then experience TOT states in respect of some of those items, just as normal participants do.

Thus, the aim of the present study was to see if participants under lorazepam experience more phenomenological TOT states after commission errors than control participants. Given that lorazepam participants made more commission errors (Bacon et al., 1998; Izaute et al., 2004; Massin-Krauss et al., 2002), we predicted that the general cognitive process of memory search is slowed down by the drug and, therefore, that the participants under lorazepam should manifest more commission TOT states than placebo participants (Brown, 1991). The subsequent resolution ability (i.e., recovery of the correct answer after a TOT experience) was also investigated. The literature shows that the recognition of TOT targets is usually good (Schwartz, 2002b). We conjectured that the phenomenological TOT states should also predict recognition here. It was hypothesized that retrieval performance in a recognition task of the commission TOT states should be equivalent to the performance of placebo participants because in previous studies lorazepam has not affected recognition performance, only recall performance (Bacon et al., 1998).

5 Experimental Ways to Capture a Particular TOT State

Diary studies have allowed for the collection of some information about the occurrence of a TOT state in a natural setting. Brown and McNeil (1966) were the first researchers to design an experimental paradigm for inducing TOT states in a controlled setting. The TOT states were precipitated by presenting students with definitions of low frequency English words and asking them to recall the words. Since then, several researchers have focused on this question. Schwartz et al. (2000) devised an experimental paradigm that seemed highly interesting for the study of lorazepam, especially as previous research tended to focus only on omission errors (Koriat,

1993). Using the paradigm devised by Schwartz et al. (2000) it is also possible to explore a TOT state occurring after the participant has provided an incorrect recall; this was called "commission TOT state". In the procedure developed by Schwartz et al. (2000) participants were presented with general knowledge questions, and those who were unable to recall the target word were asked whether they were experiencing a TOT. The TOT states were assessed after both omission and commission errors. In addition, after a commision error, participants were informed that their response was incorrect and subsequently asked whether they were now experiencing a TOT. It was observed that in some cases, a phenomenological TOT could occur once a person was made aware that her/his first response was incorrect. Moreover, in the Schwartz et al. (2000) study the commission TOT state had the same general properties as the omission TOT state. In particular, following a comission TOT state, participants were more likely to retrieve the correct target later on than when they did not experience the phenomenological TOT. This is exactly what we expected to happen, that is, eventual retrieval of the correct target word would occur more frequently under the effet of the amnesic drug lorazepam. In the following study, we were keen to see whether this effect would be exaggerated in lorazepam participants.

6 The Experiment

The experimental procedure was based on Schwartz et al. (2000). For a complete description see Bacon et al. (2007).

6.1 Stimuli

The stimuli were 100 general knowledge questions. In the recognition task, participants were offered five possible answers, including the correct one. Except from the 100 questions, 20 unanswerable questions were also presented; most of them were taken from Schwartz et al. (2000; e.g., "For which country the monetary unit is the jaque?"). These 20 questions sounded plausible but had no correct answer (e.g., no country has a monetary unit called the jaque).

6.2 Participants and Experimental Design

Participants in the study were 30 healthy, French native-speaking students from Strasbourg University. They were pseudo-randomly assigned (on the basis of age, weight, and general knowledge) to one of two parallel groups, that is, a placebo group ($n = 15$) and a lorazepam 0.038 mg/kg group ($n = 15$), taking into account 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 were not significantly different in terms of age, $t(28) = 0.07$, *ns*, of weight, $t(28) = 0.05$, *ns*, or of pre-drug general knowledge as assessed using the Information subtest, $t(28) = 0.61$, *ns*, and Vocabulary subtest, $t(28) = 0.87$, *ns*. Informed written consent was obtained from all volunteers before they embarked on the study, which was approved by the Faculty Ethics Committee.

The drug capsule was given orally in a double-blind procedure. Each participant was tested individually in the presence of an experimenter. The questions were displayed on the computer screen one at a time. Participants were given an explanation of the term "tip-of-the-tongue". It was drawn to their attention that they should not confuse a TOT experience with a very strong feeling of knowing. They were also informed that the TOT experience is relatively rare, and that they might not experience it at all in the course of this experiment. These instructions were given to avoid the risk of an artifactual TOT state – Widner et al. (1996) suggest that participants might sometimes express TOT states just to avoid appearing uneducated in front of the experimenter. Participants were asked to give the answer aloud or to say "I don't know". If they indicated they did not know the answer (omission errors) or provided an incorrect response (commission errors), they were asked if they were in a TOT state. In the case of answerable questions, the questions were displayed a second time, and each participant then made a feeling-of-knowing judgment, as a prediction of successful recognition of the correct answer from among a total of five answers. Finally, the participants completed a recognition test in case of answerable questions.

At the end of the study participants were required to rate their sedation state using a set of 16 visual analogue scales (Norris, 1971). Overall, sedation scores were higher for the lorazepam group ($M = 36.6$; $SD = 14.1$) than for the placebo group ($M = 23.8$; $SD = 13.3$), $t(28) = 2.5$, $p < 0.05$. Pearson correlations were also calculated between the sedation score and the memory and metamemory performance levels. No significant correlation was found in either group between self-ratings of sedation and recall performance and mean feeling-of-knowing results.

7 Results

7.1 Memory Performance

Memory performance scores (see Table 5.2) confirmed the previous observations (Bacon et al., 1998), since the mean proportion of total answers in the recall phase was not significantly different between the two groups, $t(28) = 0.2$, $p = 0.86$. Also, lorazepam participants' ratio of commission errors was higher than that of placebo participants, $t(28) = 2.3$, $p < 0.05$. Lorazepam participants did not give significantly more answers ($M = 3.4$, $SD = 1.80$) than the placebo participants ($M = 2.5$, $SD = 1.86$) to the unanswerable questions, $t(28) = 1.2$ $p = 0.26$. The recognition performance of

the two groups was not significantly different, $t(28) = 1.2$, $p = 0.23$. Thus, lorazepam impaired semantic memory performance only when participants had to recall the correct anwer.

7.1.1 Occurrence of TOT States

Of the 30 participants, seven (three from the lorazepam group and four from the placebo group) did not produce any of the two types of TOT. The lorazepam participants experienced more commission TOT states than placebo ones (see Table 5.3). However, the individual TOT percentages were similar in both groups, as there was no difference between the proportion of TOT states produced after an omission error, $t(27) = 0.26$, $p = 0.80$, or between the proportion of TOT states produced after a commission error in placebo groups and lorazepam, $t(25) = 0.2$, $p = 0.86$. Thus, lorazepam participants had more commission TOT states because they made more commission errors. The analysis of the commission TOT states showed that the nature of the errors was similar in both groups, with most of them being semantically related to the target word. The proportion of semantically

Table 5.2 Mean (and *SD*) proportions of answers in the free recall and recognition tests in the placebo and lorazepam groups (adapted from Bacon et al., 2007)

	Group	
	Placebo	Lorazepam
	M (*SD*)	*M* (*SD*)
Free recall test		
Total of answers	0.76 (0.08)	0.76. (0.10)
Correct answers	0.79 (0.09)	0.70 (0.12)*
Commission errors	0.21 (0.09)	0.30 (0.12)*
Recognition test		
Correct answers	0.84 (0.05)	0.81 (0.06)
Commission errors	0.16 (0.05)	0.09 (0.06)

*Significant difference at $p < 0.05$

Table 5.3 Frequencies of omission and commission TOT states, of semantically related commission TOT states, and means (and *SD*) of individual proportions of the respective TOT states in the placebo and lorazepam groups

	Placebo group	Lorazepam group
Frequencies		
Total of TOT states	166	184
Omission TOT states	117	108
Commission TOT states	49	76
Semantically related commision TOT states	48	72
Means (and SD)		
Individual proportion of TOT states		
Omission TOT states	0.33 (0.18)	0.32 (0.15)
Commission TOT states	0.24 (0.19)	0.25 (0.17)

related commission TOT states to overall number of commission TOT states was 0.98 and 0.95 for the placebo and lorazepan groups, respectively with no significant difference between them, $t(21) = 1.0$, $p = 0.33$.

7.1.2 Resolution of TOT States

"Resolution" is the likelihood that a TOT state was followed by subsequent correct recognition of the target answer. For placebo participants, the resolution rate in the case of a TOT state ($M = 0.83$, $SD = 0.10$) was significantly better than after a non-TOT state ($M = 0.60$, $SD = 0.06$), $t(13) = 8.3$, $p < 0.01$. For lorazepam participants, resolution in the case of a TOT state ($M = 0.73$, $SD = 0.10$) was only marginally better than that of a non-TOT state ($M = 0.59$, $SD = 0.11$), $t(13) = 2.1$, $p = 0.054$. The difference between the TOT resolution rate of placebo and lorazepam participants was not significant, $t(27) = 1.3$, $p = 0.19$.

7.1.3 Metamemory Characteristics of the TOT and Non-TOT States

The mean feeling-of-knowing judgments did not differ between the placebo and lorazepam participants, $t(28) = 0.26$, $p = 0.80$, *ns*. The mean feeling-of-knowing judgments were significantly higher after a TOT state than after a non-TOT state, $F(1,27) = 158.6$, $p < 0.001$. There was no difference between the placebo and lorazepam group, $F(1,28) = 0.004$, $p = 0.95$. The predictive accuracy of TOT states on recognition, computed with the gamma correlations (Nelson, 1984), was preserved by the drug as the gamma correlations between TOT states and recognition were not significantly different for the placebo and lorazepam participants, $t(26) = 1.2$, *ns*. Similarly, the predictive value of feeling-of-knowing judgments on recognition was not curtailed by lorazepam, $t(28) = 0.2$, *ns*. However, the predictive value of TOT states on feeling-of-knowing judgments was significantly higher in the placebo group, $t(27) = 2.3$, $p < 0.05$. This means the lorazepam participants suffered from an impaired relationship between the two forms of knowledge monitoring (see Table 5.4).

Table 5.4 Means (and *SD*) of feeling-of-knowing judgments for answers after TOT and non-TOT states and gamma correlations in the placebo and lorazepam groups

	Placebo group	Lorazepam group
	M (*SD*)	*M* (*SD*)
FOK judgments in TOT states	75.6 (14.8)	68.1 (17.1)
FOK judgments in non-TOT states	38.6 (17.4)	46.1 (18.7)
Gamma correlations		
TOT and recognition	0.55	0.37
Feeling of knowing and recognition	0.36	0.35
TOT and feeling of knowing	0.86	0.67*

*Significant difference at $p < 0.05$

8 Discussion

The present study was undertaken in order to investigate whether the higher number of incorrect recalls by participants under the effect of the amnesic drug lorazepam in a general knowledge task could be attributed partly to the fact that they experience more recall failures that can be identified as specific kinds of TOT, that is, commission TOT state (Schwartz et al., 2000). It was hypothesized that participants under the effect of the amnesic drug lorazepam would experience more often a cognitive TOT state (i.e., the failure of the process to retrieve a known word), which becomes a phenomenological TOT state (i.e., the strong feeling that a particular word is on the verge of being retrieved) only after they became aware of the retrieval failure. We also wanted to confirm that the cognitive and the phenomenological TOT states can be dissociated. Finally, given that a TOT state reveals a conflict between the cognitive and metacognitive levels, we suspected that the anxiolytic and anticonflict effects of lorazepam may be partly responsible for the mechanisms and occurrences of commission TOT.

Thanks to further analysis of findings by Bacon et al. (1998) and Massin-Krauss et al. (2002), we have confirmed some preliminary conditions for the workability of the model of TOT state as an explanation for the pattern of semantic memory/metamemory impairment induced by lorazepam.

The research undertaken to confirm the hypothesis produced conclusive results. As observed in the previous experiments, both lorazepam and placebo participants gave the same number of recall answers to a set of general knowledge questions. However, the lorazepam participants made more recall errors and experienced more TOT states following retrieval errors than placebo participants, whereas resolution of the TOT state (the ability to recognize the correct answer eventually) was unimpaired. The group of participants having received lorazepam reported 29 more cases of commission TOT states than the placebo participants. The eventual analysis of the memory and metamemory characteristics of these commission TOT states revealed that the commission TOT states experienced under lorazepam were similar in all respects to those experienced under placebo and in everyday life. Consequently, the difference induced by lorazepam in respect of commission TOT state is only quantitative, that is, commission TOT state is more frequent under the effects of the drug than under a placebo. So, it would seem that the impaired recall performance of participants under lorazepam could indeed be partly due to dissociation between the phenomenology and cognitive process of a TOT state, that is, the participant would be in the cognitive state of a TOT, which implies that she/he knows the correct target but that this target is temporarily inaccessible. In addition, a persistent alternate would come to mind, but unlike what occurs in the case of normal participants experiencing a TOT state, the cognitive aspect of the situation would not be accompanied by the feelings characteristic of a TOT. Because there is no phenomenological TOT occurring alongside the retrieval failure, the persistent alternates are produced as answers and end up being recorded as commission errors. This seemed to be confirmed insofar as lorazepam participants, overall, experienced more commission TOT states, and their recognition ability was preserved.

8.1 The Mixed Effects of Lorazepam on Semantic Memory and TOT State

The benzodiazepine lorazepam drug does not radically disturb semantic processes. Semantic memory, when evaluated with tests of verbal fluency, remains largely unaltered under the effect of benzodiazepines, suggesting that overall accessibility to the semantic store is largely unaffected by lorazepam. The questionnaire used in the present study differs in many respects from the sentence verification and fluency tasks, in particular because it requires participants to give their own individual answers to general knowledge questions. The profile of the lorazepam group's performance, characterised by a preserved number of answers in the recall task and low percentage of correct answers in the recall task, indicates that the drug does not impair performance by reducing accessibility to information. The present observations could explain the coexistence of semantic memory impairment, as observed in general knowledge tasks, with the preserved performance of lorazepam-treated participants in verbal fluency tasks. Some of the authors who have used fluency tasks also observed a slowing down of the reaction time (Brown, Brown, & Bowes, 1983; Green et al., 1996; Vermeeren et al., 1995). In verbal fluency tasks, the slower-than-normal retrieval process brought about by the drug seems not to curtail its efficiency. This was not the case for general knowledge questions which are more demanding and require the retrieval of a single correct answer.

On the other hand, the cognitive TOT state is usually regarded as a slowing down of the normal retrieval phenomenon (Brown, 1991). Under the effect of benzodiazepines a cognitive TOT state seems to occur more often than in healthy individuals, and the wide range of different recall errors is also an argument in favor of the possibility that lorazepam participants remain stuck in one of the preliminary stages of lexical search (Miozzo & Caramazza, 1997). As most of the errors were semantically related to the target, preserved accessibility to the semantic store would allow items belonging to a general category to be provided correctly, but not necessarily the single correct answer corresponding to the question pointer.

The monitoring failure in the case of commission TOT state is the inability to detect the temporary inaccessibility of the correct target answer. Koriat (1998) argued that "the key to 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). This suggests that the failure to spontaneously experience the phenomenological TOT in the case of commission TOT states could also inflate confidence with respect to the persistent alternate. However, after the commission error is revealed, the partial information may serve again to trigger a TOT experience. Schwartz and Smith (1997) observed that participants used the products of retrieval as a source of information for phenomenological TOT states. This would help to explain the emergence of TOT phenomenology after the participant has been told his/her response is incorrect. Some additional cues from the current experiments with lorazepam also lend support to this hypothesis, that is,

greater accessibility to related information under the effect of lorazepam may be inferred from the wide range of different commission errors produced under lorazepam.

8.2 The Anxiolytic Effect of Lorazepam on Phenomenological TOT State

When people experience a commission TOT, they do not feel the phenomenological TOT, that is, the anxiety and the conflict. The benzodiazepine lorazepam is an anxiolytic drug with well known anticonflict effects that alleviates emotions (Harvey, 1980; Kleven & Koek, 1999; Vanover et al., 1999). It seems likely that the anxiolytic effect of lorazepam has eliminated the conflict resulting in a dissociation between the phenomenology and cognitive component of a TOT state. When under the effect of lorazepam, people are more likely not to be aware of the emotional conflict between the persistent alternate and missing correct answer. Consequently, they are also more likely to report the persistent alternate with greater frequency. However, when it is brought to their attention that they are wrong, the state of retrieval failure becomes identifiable, triggering the phenomenological TOT state. Thus, in a sense the lorazepam masks the emotional state created by the TOT conflict, allowing more commission errors to be made, but then subsequently producing more TOT states. According to what happened under lorazepam, consciousness does not necessarily mirror the process under way, and it is possible that with commission TOT states we have experienced an additional type of TOT resolution, namely emotional resolution. Indeed, in a commission TOT state there is no conflict because there is no emotion. However, the price to be paid for this absence of conflict is a memory failure, since participants give the persistent alternate as the genuine answer. So, in fact, this would be a counterproductive resolution of the TOT conflict in commission TOT states. However, feedback allows the participants, either under placebo or lorazepam, to experience the phenomenology and eventually to retrieve the correct answer. This means, therefore, that identifying the existence of a cognitive conflict seems to be necessary for the cognitive problem to be correctly solved. Yet, in daily life we do not necessarily have the good fortune of receiving feedback about what we say, and this may be problematic for people using benzodiazepine as drug to alleviate their anxiety, particularly as it seems there is no complete tolerance to the drug's amnesic effects.

9 Conclusion

In summary, as predicted, the lorazepam-treated participants experienced TOT after an incorrect recall more often than placebo participants. However, their ability to resolve TOT states (to find the correct answer eventually) was preserved in

a subsequent recognition task, and the cognitive and metacognitive characteristics of the TOT state were also preserved by the drug. The impairment caused by lorazepam in a general knowledge task to assess semantic memory might therefore be partly the result of a greater sensitivity to a very common memory error, the cognitive TOT state, probably because lorazepam-treated participants spend longer than normal participants in a very preliminary state of memory search. Participants under lorazepam seem to experience dissociation between the phenomenology and cognitive process of the TOT states. This peculiar means of conflict resolution may be interpreted in light of the drug's anxiolytic effect.

Cognitive commission TOT state seems to be real and plausible entity corresponding to a particular cognitive and metacognitive state. In commission TOT states, resolution of the TOT conflict seems to be emotional, involving suppression of the phenomenological feelings, but at the cost of an incorrect answer. The anxiolytic and anticonflict effect of benzodiazepines seems to play a part in the more frequent occurrence of these specific memory blocks. Retrieval of the phenomenological TOT seems necessary to overcome the block created by persistent alternates in an appropriate manner. The use of lorazepam allowed us to further our understanding of the possible mechanisms of the TOT experience. Of interest as regards lorazepam is that we experimentally increased the number and diversity of persistent alternates retrieved while keeping correct recognition constant; this could provide a good tool for psychologists and linguists keen to study the effect of persistent alternates on the TOT process. To precipitate TOT states in healthy people, researchers have provided the participants with words that are potentially plausible persistent alternates (Smith, 1994). With lorazepam, we caused the drugged participants to come up with their own natural, "endogenous" persistent alternates that may be of interest for further investigating the TOT processes. Insofar as the retrograde drug-induced impairment of semantic memory is temporary and reversible following acute administration of lorazepam, further investigations into the exact nature of these semantic failures might be of interest for gaining a better understanding of the memory deficits that may occur in both healthy participants and patients suffering from organic amnesia.

We are conscious of the fact that many of our arguments are quite speculative and need further investigation. Moreover, it is possible that different amnesic drugs or different pathological conditions (Matison, Mayeux, Rosen, & Fahn, 1982) could lead the person to become stuck in a different step of the retrieval process, and further research is needed to explore that possibility. The effects of lorazepam on semantic memory may not be generalized to include the other molecules of the benzodiazepine family, because the literature shows that the patterns of cognitive impairments induced by benzodiazepines may vary greatly from one molecule to the next (Curran, 1999). In particular, it seems that lorazepam is very different in a number of respects, especially as regards the effects on cognition (Giersch et al., 2010). To the best of our knowledge, there is only one study of another molecule from the same family, triazolam, that has been conducted using a general knowledge task (Mintzer et al., 2010), and in that study the researchers observed no effect of triazolam on recall ability. So it would be interesting to explore the effects of the other molecules in the family.

In the meantime, it seems obvious that lorazepam induces other semantic deficits. In the study presented here, lorazepam also induced more perseverative errors, and the Moses illusion paradigm enabled us to reveal another kind of subtle, highly specific and reversible impairment that may often go unnoticed in everyday situations (Izaute et al., 2004). Studies into the long-term effects of benzodiazepines on cognitive functions suggest that tolerance to the memory impairments caused by benzodiazepines never fully develops (Barker, Greenwood Jackson, & Crowe, 2004; Stewart, 2005). Consequently, these specific semantic impairments may severely compromise the normal conduct of day-to-day activities for the vast numbers of chronic lorazepam users throughout the world.

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