Modelling the Tip-Of-the-Tongue State in Guided Propagation Networks

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Abstract. We start by presenting the **T**ip-**O**f-the-**T**ongue (TOT) problem and some theories accounting for it. We go then on to consider it within the framework of a neurobiological, computational model: Guided Propagation Networks (GPNs). "Selective facilitation", a feature of the model, allows us to formulate and test various hypotheses accounting for the impeded access to a target word. We will illustrate and test them via a computer program simulating the TOT state. A comparison with other "spreading activation" models is proposed in the final discussion, as well as an evaluation of the proposed hypotheses. The abstract should summarize the contents of the paper and should contain at least 70 and at most 150 words. It should be set in 9-point font size and should be inset 1.0 cm from the right and left margins. There should be two blank (10-point) lines before and after the abstract.

1 Introduction

When the mental lexicon is contacted to access a specific word, the latter is retrieved quickly and apparently without too much effort. This is the default case, i.e. the most frequent situation. Unfortunately, there are cases when things go awry: one fails to produce the needed target word. This kind of failure may be related to the speaker's ignorance of the target word, or, and this is the case we are interested in, to her/his inability to access the right word, even though s/he knows it. This has often been dubbed as tip-of-the-tongue (TOT) phenomenon.

Just as studying other dysfunctions of the human mind, analyzing TOT problems may help to gain a better understanding of the structure of the mental lexicon, hence inspire computational models allowing the simulation and support of Natural Language Production (NLP).

A typical feature of the TOT phenomenon is that people who are experiencing it have a strong **f**eeling **o**f **k**nowing (FOK) that the retrieval of the target word is very close [7], [28]. This feeling of imminence can be sustained by the fact that people feel that they know the word, and that it is about to pop up, ready to cross their lips at any moment. Indeed, next to conceptual knowledge, people seem to know a lot of other things concerning the form of the target word [6]: number of *syllables*, *beginning / ending* of the target word, *part of speech* (noun, verb, adjective, etc.), *origin* (Greek or Latin), and even *gender* [30]. Strangely enough, the resolution of the problem

occurs spontaneously, possibly at a time when deliberate retrieval attempts have been abandoned [7], [25].

Existing models of word production provide assumptions concerning the origins of the TOT. Following a brief presentation of these systems, we will consider the TOT problem within the framework of Guided Propagation Networks (GPNs), a special kind of computational model able to simulate word production. We present then three hypotheses to model the TOT-phenomenon within the GPN framework: low-frequency assumption, low-facilitation, and depressed internal flow. Finally, we compare this work with other approaches.

2 Models of Lexical Production

Observations of naturally occurring TOTs, diary studies, as well as laboratory studies suggest that at least some TOTs are caused by the blocking of the target word. Several hypotheses have been offered and tested, including the *blocking theory* (e.g., [28]) and the *partial activation theory* (e.g., [16]).

2.1 Psychological Models of the TOT

The *blocking theory* states that TOTs can occur when plausible, but incorrect answers pop up in the speaker's mind. As Woodworth has noted already 80 years ago [31] similar words can cause this kind of blockage or inhibition of the target word.

The *partial activation theory* states that the TOT represents incomplete activation of a target word, the latter failing to reach the necessary threshold. Research supporting this theory reveals that partial information about a target word, such as its first letter or the number of syllables, are commonly available even though the word itself rests eluded (e.g., [11]). Hence, definitions paired with phonologically related cue words (for example, 'abstract' to prime 'abdicate') can free people from the TOT state, helping them to access the phonological form of the target word (e.g., [16], [22]).

The production of a given word is usually viewed as starting with the activation of semantic information, followed by the specification of a syntactic representation, before the retrieval of the phonological components of the word (e.g., [5]). According to this view, the TOT phenomenon is the result of a **T**ransmission **D**eficit (TD), i.e. a lack of strength of the connections transmitting activation to the phonological representations [8], [21]. Retrieval thus fails because of the incomplete activation of representations (see [7] for a review).

According to the TD model, a TOT would occur when the strength of the connections among phonological nodes is too weak to transmit sufficient activity towards all the phonemes of the target word. Recent and frequent activation of nodes strengthens connections, therefore increasing transmission. Because connection strength decreases over time if no activation has taken place, the TD model explains why this phenomenon concerns low- rather than high-frequency names or words [8], [14], [24].

2.2 Guided Propagation Networks

The ability to take instantaneous decisions based on the unconscious integration of many pieces of information is one of the most striking features of our brain. This works fine most of the time and without any apparent conscious effort, unless, something goes awry like in the case of the TOT problem. This is where **G**uided **P**ropagation **N**etworks (GPNs) become useful, as they are based on the detection of coincidences between various flows of information across time. Their **spontaneous flows of activity** allow them to respond even in the absence of stimulation, a main feature for applications in both Artificial Intelligence and neuronal modelling. GPNs are also supported at a physiological level by the spatio-temporal integration properties of the *Post-Synaptic Potentials* for neuronal input [18].

A GPN is composed of several modules which work in parallel. The peripheral ones code low-level information (letters, syllables), and stimulate deeper modules containing more complex information (lexical, semantic, syntactic). Conversely, deeper, or more central modules ease the activation of the peripheral modules by temporary decreasing their propagation thresholds (Fig. 1).

For a given module, appropriate propagation of activity along *memory pathways* relies on the coincidence of: (1) the spontaneous flow generated at the root of the module, (2) incoming stimuli from more peripheral modules, and (3) the facilitation provided by more central modules. Cells are meant to detect this coincidence. The contribution of these three flows has to be well synchronized at the level of each cell for the host module to run properly.

In a GPN module, the spontaneous flow is guided towards target output "event detectors". This is due to its coincidence with incoming stimuli and the facilitation generated by other modules. In sum, the spontaneous flow will follow the pathway made of a chain of cells with the lowest thresholds, stimulated across time by the module's input.
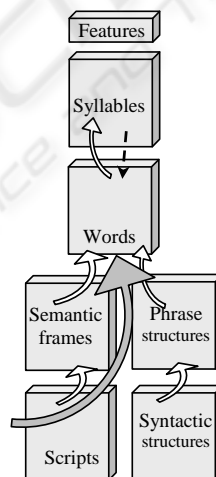

Fig. 1. GPN production modules. The white arrows pointing upwards stand for facilitation flows. The grey arrow at the front comes from a neuromodulation-like module, facilitating words of a certain emotional value.

2.3 Lexical GPN Production Modules

In mammals, *proprioception* is an essential 6th sense through which the brain perceives what the body is doing [27]. In a GPN production module, the spontaneous flow is sucked up along a specific pathway by the facilitation signals generated by deeper modules. The internal *proprioceptive* stimuli are used to control the movement sequencing and to avoid Parkinson-like effects [29].

Word generation is performed in two steps:

Phase 1: a wave of "threshold decrease" is instantaneously propagated backwards a given lexical pathway.

Phase 2: When this "backward facilitation" reaches the first cell of the pathway, due to the priming by the spontaneous flow, a dam is opened: the activity flows towards the next cells, including those whose threshold has just been decreased. The spontaneous activity bypasses the latter a bit, but not enough to cross a third one. For this to happen, the proprioceptive stimulus, signalling that the first syllable has just been generated, is expected to provide its own contribution to the internal flow, which will then cause an overflow of its contribution to the third cell. The process continues along these lines until the end of the pathway is reached (Fig. 2).

For this procedure to run properly, three conditions must be met: (1) the backward facilitation wave must be well regulated, (2) the spontaneous flow must be present at the beginning of the pathway, and (3) proprioceptive stimuli must be produced by more peripheral modules (i.e.: syllables). Otherwise, the internal flow may proceed either too fast towards its target and be of too low intensity to produce the syllables in the right order, or the activation is too low to reach its target, yielding problems akin to the TOT phenomenon.

There are three factors likely to influence the propagation of the internal flow towards the end of a pathway:
- the threshold resting level
- the intensity of the threshold offset
- the weight of the internal flow

Before getting more into details, a failure in the full activation of the lexical pathway can be the result of an "excessively high" value of the threshold level prior to the facilitation process. Conversely, the failure may also be the result of a lack of decrease of the threshold during facilitation. Third, it may be the result of a depressed internal flow. The second possibility may arise when the value of the offset depends on several factors, some of which being absent at the moment of trying to produce the target-word. This holds only for the major lexical categories (nouns, verbs, adjective, adverbs). In this model, 'minor' categories (determiners, preposi-tions, etc.) are only triggered by a strong single syntactic input. They never cause a TOT-state.

As one can see by looking at the architecture depicted in Fig.1, every meaningful word stays under the influence of several facilitating factors: syntactic, semantic, emotional. For example, the syntactic facilitation flow may touch *nouns*, while words of a certain semantic frame are facilitated at the same time; words of the current emotional value may also be focused on. The "best" candidate among the words to be generated has the greatest intersection of the different subsets.
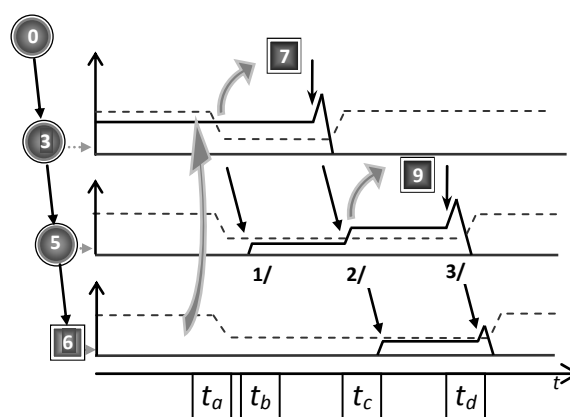
Fig. 2. <u>Well-regulated activity of a production pathway</u>. At the left-hand side, you can see a pathway starting by the internal flow generator (cell n°0) ; from top to bottom, the following cell n°3 is aimed at producing a first syllable (i.e.: *MI*); cell n°5 generates the 2nd syllable (*LAN*), and the square cell n°6 represents the related full word (which is *MILAN*). The horizontal axes stand for the time dimension in the diagrams of activity (vertical axes); the cells' response thresholds are represented by dotted lines. The backward facilitation generated by a deeper module (long, grey arrow pointing upwards) results in a threshold decrease. While this threshold decrease does not affect the inactive cells (5 and 6), it does induce the response of the first cell of the pathway (n°3), because of the preactivation due to the internal flow (top diagram). The cell n°3 reacts to this by sending an activation signal to its offspring (n°5), and a facilitating signal to the syllable-effector n°7. Once this syllable is uttered, its effector stimulates cell n°3 with a "proprioceptive" feedback, which allows the internal flow to move forward. The spontaneous flow eventually reaches the end of the path (bottom diagram), with cell n°6 sending a "proprioceptive" stimulus to the deeper modules.

According to this view, two mechanisms are used to produce the appropriate word:

1/ decision thresholds associated with each word can be regulated in such a way that only words having received all the energy become fully active.

2/ mutual inhibition between the remaining candidates simulate a competition where only the most activated candidate, i.e. word, wins.

The labels t_a, t_b, t_c and t_d of the figures here below correspond respectively to four time slices represented along the horizontal axis of Fig. 2.

3 Exploring Three Hypotheses

Human language production would not work if all possible words for a given slot were considered serially before being selected. Parallelism is an efficient means to choose instantaneously one among the possible candidates, as long as the involved mechanisms work properly.
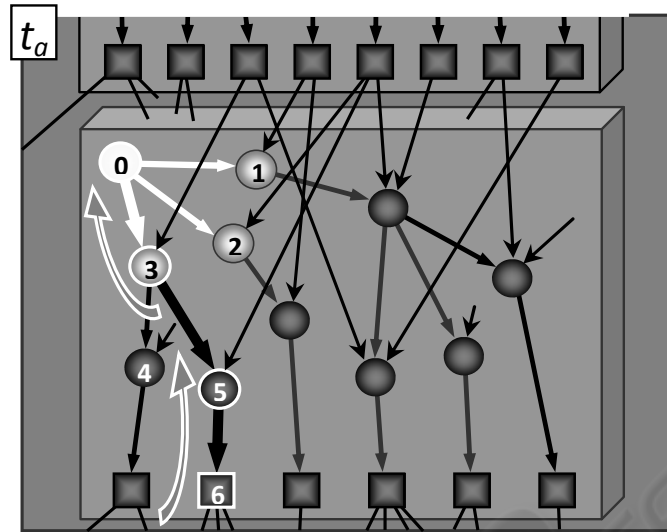
Fig. 3.a. "Word" production module fed by a "Syllable" module whose effectors appear at the top (row of square cells). Before being aspirated in a specific direction by a facilitation signal, the spontaneous activation of the root unit (n° 0) can potentially feed in parallel every pathway of the module. If the word effector n°6 is facilitated by deeper modules (not represented here), a threshold decrease proceeds upwards (white and grey arrows) towards the root, touching its constituent cells.
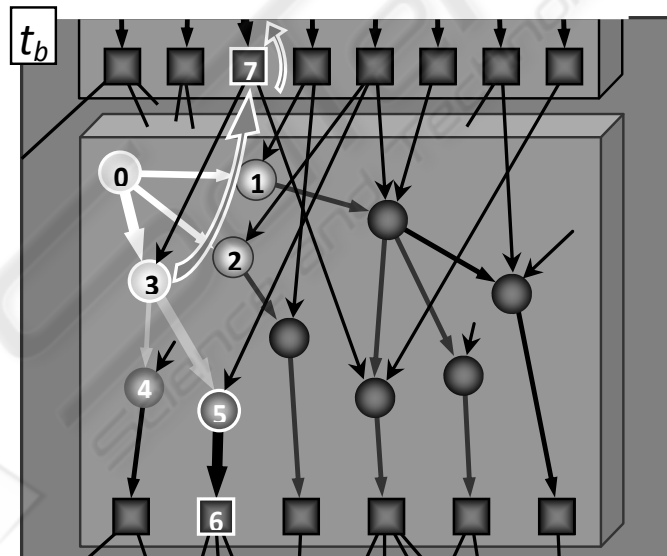

Fig. 3.b. The response threshold of cell n°3 has decreased and can now be reached by the spontaneous flow generated by the root cell (n°0). Cell n°3 sends a slight activation signal towards cells n°4 and n°5, and a facilitation signal up to the syllable effector n°7. The pathway to the latter yields now the production of its associated syllable-pattern of activity.
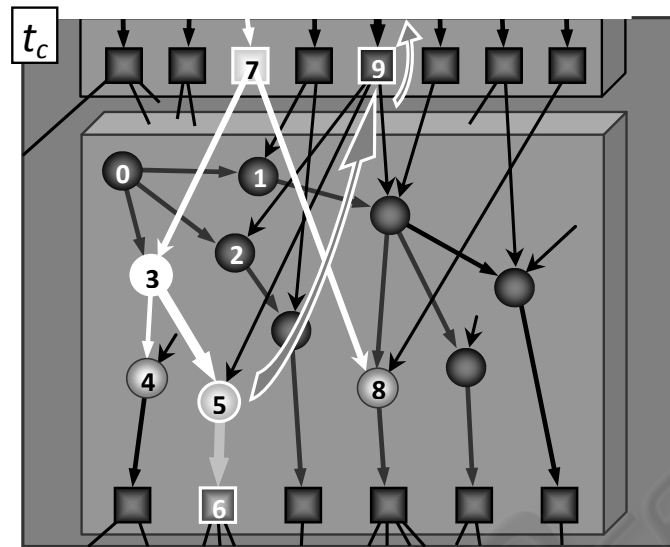
Fig. 3.c. When the syllable is generated, the corresponding effector (n°7) gets fully activated by the contextual flow of its module, spreading then activation towards the cells 3 and 8. Cell 3 has been waiting for this feedback to re-activate cell 5 (as well as cell 4 which has not been facilitated). The same process applies again, facilitating the pathway of the syllable-effector 9.
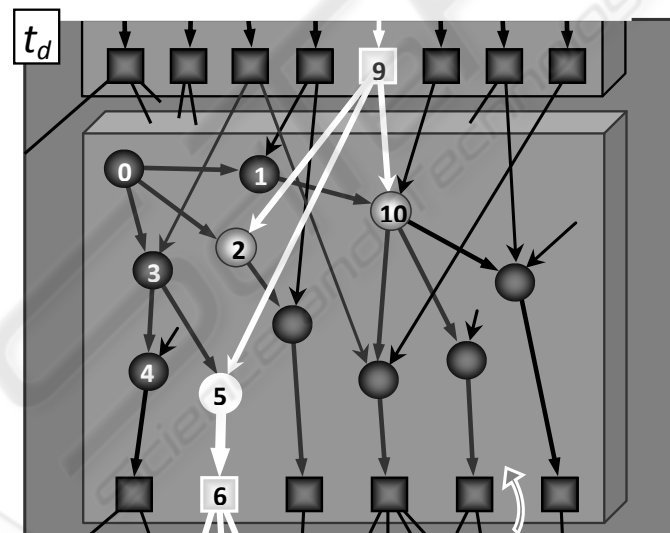

Fig. 3.d. At the end of this process, the word effector n°6 gets fully activated, indicating via activation of deeper modules that the associated word production is completed. The next word can be triggered in the same way by deeper modules (white and grey arrow at the bottom-right).

3.1 The Low-frequency Assumption

The TOT state can be experimentally induced by presenting an image or a definition of a low-frequency object [15]. The frequency (or familiarity) factor seems to be quite important in the case of temporary lexical amnesia characterizing the TOT. It may be considered together with the "never-ending learning" schema that allows GPN modules to grow from scratch [3].

In this theory, the occurrence of an unexpected series of internal stimuli results in the sprouting of a related pathway inside a GPN module. In agreement with recent data showing that new neurons are continually born throughout adulthood [23], new GPN cells are used for pathways to autonomously grow whenever needed in the course of the "system life". The following selective consolidation and general extinction, which both apply to lexical pathways, provide an efficient way for separating meaningful items from noise. Thanks to this continuous process, a snapshot of the lexical landscape may contain the most frequently used paths or "highways", living together with newborn "tracks". While being beneficial for the access of very-frequent words, this kind of selective process may also impede the retrieval of rare items. Hence, the TOT phenomenon could be considered as a simple side-effect of a more general learning principle.

Rare words, or those that have not been used much recently, would then have a high propagation threshold resting level. The dynamic threshold decrease which triggers a lexical production would fail to aspirate the spontaneous flow.

3.2 The Low-facilitation Assumption

As mentioned already, the thresholds resting levels of cells which form a word-pathway are heavily decreased for the word about to be generated. As shown in Figure 1, there are at least three factors accounting for the decrease of these thresholds, hence, its generation: syntactic, semantic and emotional facilitations. Only the connection between syntactic and lexical dimensions seems to be well preserved in TOT. Emotion may interfere in several ways with the generation of a word:

- Emotional guiding. According to newer theories of the brain architecture, part of the cortex stores the emotional value of our experience to promote behaviour which proved to be rewarding [10]. Applying this strategy to word production may result in blocking words associated with negative events.

- Mismatch between emotional values. Among the dimensions determining the word to be generated at a certain moment, the emotional value associated through learning with full-fledged words can be compared with the "general mood" of the current generation process. Generation of words experienced as rather 'positive' may for instance be inhibited in case of negative mood.

3.3 The Depressed Spontaneous-flow Assumption

Given a possible correlation between the strength of the spontaneous flow and the *Serotonin* neuromodulator [29], a lack of serotonin, as found when being in a depres-

sive state, may impede the generation of a target-word. This view is compatible with studies showing a higher rate of TOT states for depressed people [1].

3.4 Relevance of Learning

The TOT-state seems to be only a retrieval problem, since the internal representation of the target word exists, but cannot be fully accessed in time. The word may be retrieved later on, incidentally, without any extra learning.

However, a mismatch between the cumulative knowledge associated with a target word and the current situation may result in a TOT effect. For instance, an accidental event occurring during the initial acquisition of a word may impede later on its production in normal conditions. Learning by imitation is allowed by the homogeneity of GPN modules: the perception of a new word generates a new pathway to be used later on in the production mode before an autonomous "production" pathway is created [4]. A possible implication of this unsupervised strategy and the TOT has not been considered here, as it falls outside the scope of this paper.

4 Computer Simulation

A full simulation of the TOT state would require a complete lexicon, with words of various types and emotional values. Right now, we are interested in the low-level mechanisms causing or accounting for the failure to produce a given target-word represented in a GPN pathway. This first experiment does not account for the possible mutual inhibition between candidate words, neither does it include emotional mismatches like those that may occur in real life.

The GPN software used here is a prototype of a GPN translator, where French and English are respectively the source and target language [4]. The "production" modules are shown in Fig.1. "Perception" modules are organized according to a similar architecture. They send facilitating signals to their "production" counterpart in the course of processing. In this way, the production of a given word depends on the multiple facilitations received from the various sources: - a French word which feeds all its possible translations in English, - a semantic frame pathway feeding several words of the same meaning, - a syntactic pathway facilitating words of a certain class. The target-word stands at the intersection of all these facilitated sub-lexicons.

As always with GPN software, the dynamic links between the cells are represented by pointers attached to a source-cell data-structure, signaling the addresses in memory of other tables of data respectively associated with destination-cells. Among other information, each pointer of this kind has a weight tending to decrease slightly at each time-step of the program. Although the instantaneous value of this weight, as well as the one of other parameters (thresholds, time-delays, signal durations) is worked out by the learning algorithm, it can be adapted "manually" to achieve a given effect in this type of "local" representation. In the network's graphical interface, the user can also click on a given cell (or pathway), to display its activity over time, as shown in the next sections. A user interface has been added to this

software, allowing the propagation parameters of the GPN modules, i.e. the "lexical production", to be fixed to any value, not just the theoretical one. The resting level of the thresholds can be set to the minimum value, thus simulating the case of a recently acquired (or low-frequency) word. The temporary decrease of a pathway's thresholds that triggers the production of a word can also be reduced. In the same way, the weight of the internal spontaneous flow can be decreased to simulate a depressed activity in the module.

4.1 Simulation of Low-frequency

In the GPN formalism, two parameters determine the cell's propagation behaviour: its *excitability*, i.e. its potential to reach its propagation threshold, and the *ratio* between the *internal flow* and the *stimuli* (weight of the spontaneous flow). New cells are born with low excitability. As the cell is used, this parameter gradually increases, correlating with the familiarity of the item that the cell codes for. In order to simulate the low frequency of a word, all the cells of its associated pathways are set to the minimal level of excitability (E = 1.).
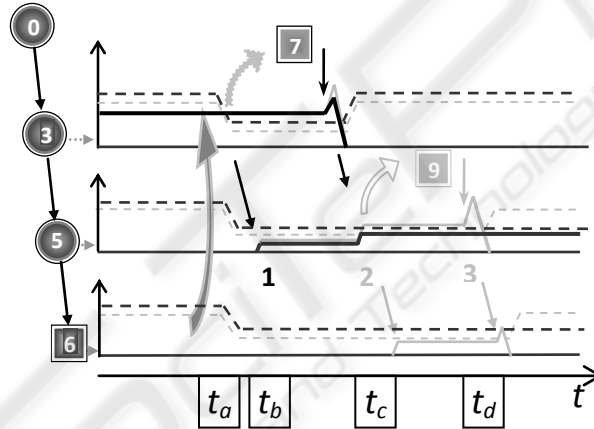

Fig. 4. Pattern of propagation along a generation pathway not frequently used (low-frequency assumption). The same diagrams as the ones shown in Fig.2 are superposed in grey, in order to allow for comparison of this basic situation with the TOT state. Here, the decision thresholds (black dotted lines) of the cells displayed at the left-hand side have been shifted to their maximum value (excitability: 1).

The decrease of the threshold is kept similar to the basic situation. The first syllable of the word (cell n°7) is activated at a lower level, hence with less intense feedback towards cell 3, whose propagated activity does not reach the threshold of cell 5. The activation remains stuck at the same sub-threshold level, and the internal flow does not spread anymore along the pathway, whatever its length (the word's number of syllables).

4.2 Simulation of Low-facilitation

The most robust value for the threshold offset provoking generation is the one at the middle of a permitted interval. For this second experiment, excitability has been set to 1.5, and the offset to 1/3 of the interval.
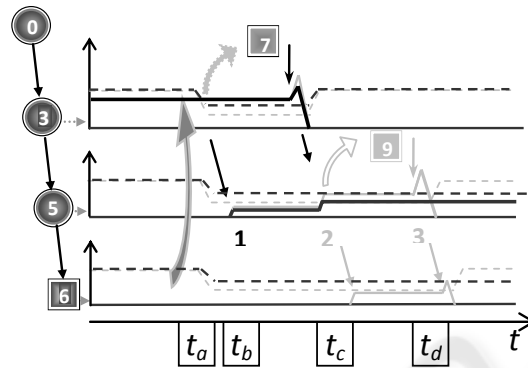

Fig. 5. Pattern of propagation along a generation pathway in which the threshold offset is depressed. Either because of an emotional mismatch, a weak connection with the current semantic con**t**ext, or because of the inhibition due to a more frequent word-candidate, the threshold decrease being half its normal value. Combining low-frequency and depressed links would simply prevent the first syllable from being activated.

4.3 Simulation of Low Spontaneous Flow

The weight of the internal flow usually follows an arithmetic progression for the intensity of the output to give a matching score of a series of stimuli and its internal representation. By setting this weight to unity all along a pathway, without updating the thresholds calculation, the spontaneous flow decreases in intensity as it proceeds towards the end of the pathway.
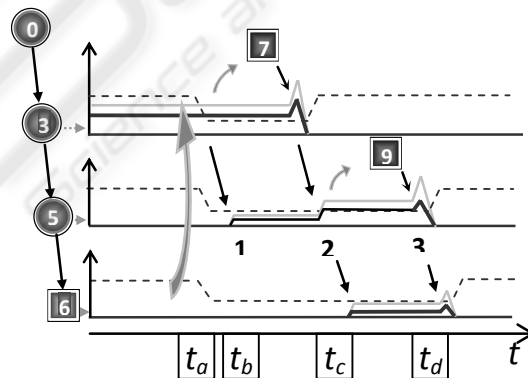

Fig. 6. Pattern of propagation along a pathway fed by a weak internal flow. The two first syllables are produced with less intensity, hence the flow cannot cross the next cell's threshold (n°6).

5 Discussion

5.1 Comparison with other Approaches

While not addressing strictly speaking the TOT problem, several computational models can be compared with GPNs: in particular those applying the "spreading activation" scheme to information retrieval.

The development of GPNs started in the 80's, while a new tide of learning algorithms was reaching the shore of Artificial Neural Networks (ANNs). Working on a pre-wired net of formal neurons – either layered or fully connected -, the supervised procedures modify internal parameters (connection weights and propagation thresholds) so that a selection of input patterns of activity - or vectors – be trained to generate another given set of output vectors.

Apart from the root-cell that initiates the internal flow, GPN modules are initially empty, instead. New cells are chained in the course of processing, when the module anticipations are not confirmed by internal stimuli. No supervision is needed. A new pathway is automatically created from the cell currently activated, provided that propagation thresholds of the concerned module are set up to their maximum value. As a matter of fact, GPN parameters only determine the status of the internal representations: flexible *Recognition*, on-line *Learning*, and flexible *Production*. The possible values of the related two parameters are not learnt, but are taken in relatively small areas [4]; they are dynamically modified either by another module or by the general algorithm standing for a central Control Unit.

The activation implemented in multilayered ANNs also spread towards lexical models in psycholinguistics. Two structures are then involved: high-level/semantic/content-related, and low-level/ phonological/form-related.

Indeed, studying performance, [13] observed that people tend to make two kinds of errors: meaning-based substitutions (*left* instead of *right*) or substitutions based on similarity of form (*historical* instead of *hysterical*). Given this fact, and given the little evidence for form choices to interfere with the semantic choices, led them to claim that lexical access is a two-step process, whose components are serially related: meaning choices taking place before form-related computations (but see [2] and [9]). The process is supposed to take place in the following way: given some information (semantic, conceptual), a *lemma* is retrieved, triggering the activation (or computation) of a *lexeme*, the lemma's corresponding phonological-, or graphemic-form. Please note, unlike for computational linguists, a *lemma* is not a concrete dictionary entry, but an abstract structure containing semantic and syntactic information (part of speech), while the *lexeme* contains the phonological form (syllabic structure, phonemes, intonation curve, etc.).

This view has led to various models. Indeed the major psycholinguistic theories of word production are all *activation-based, multilayered network models*. Most of them are implemented, and their focus lies on modelling human performance: speech errors or the time course (latencies) as observed during the access of the mental lexicon. The two best-known models are those of Dell [12] and Levelt [19] [20], which take opposing views concerning *conceptual input* (conceptual primitives vs. holistic lexicalized concepts) and *activation flow* (one-directional vs. bi-directional).

The Dell model is an interactive-activation-based theory that, starting from a set of features, generates a string of phonemes. Information flow is bi-directional, that is, lower level units can feed back to higher-level components, which may lead to errors. For example, the system might produce *rat* instead of the intended *cat*. Indeed, both words share certain components. Hence, both of them are prone to be activated. At the conceptual level (from the top) they share the feature *animal*, while at the phonological level (from the bottom) they share two phonemes. When the word node for *cat* is active, any of the following segments /k/, /æ/, and /t/ is co-activated. The latter two phonemes may feed back, leading to *rat*, which may already be primed and be above baseline due to some information coming from a higher-level component. The model can account for various other kinds of speech errors like *preservations* (e.g., beef needle soup), *anticipations* (e.g., cuff of coffee), etc.

Based on the distribution of word errors, Dell argues that some aspects of speech generation rely on retrieval (phrases, phonological features, etc), while many others (word/phoneme and possibly morpheme combinations) rely on synthesis. Since generation is a productive task, it is prone to swapping or reuse of elements.

WEAVER++ (**W**ord **E**ncoding by **A**ctivation and **VER**ification) is also a computational model. It has been designed to explain how speakers plan and control the production of spoken words [26]. The model is "hybrid" as it combines a *declarative associative network* and *procedural* rules with *spreading activation* and *activation-based rule triggering*. Words are synthesized by weaving together various kinds of information.

While WEAVER++ is also activation-based, information flow is only one-directional, top-down. Processing is staged in a strictly feed-forward fashion. Starting from lexicalized concepts (concepts for which a language has words) it proceeds sequentially to lemma selection, morphological, phonological and phonetic encoding, to finish off with a motor plan, necessary for articulation. Unlike the previous model, WEAVER++ accounts primarily for reaction time data. Actually, it was developed on the basis of such data collected during the task of picture naming. However, more recently the program managed to parallel a number of findings obtained in psycholinguistics where other techniques (chronometry, eye tracking, electrophysiological and neuro-imaging) have been used.

Again, as mentioned already, these models deal with word access in general and not with modelling the TOT problem.

Also, just as Pattern Recognition must deal with variations of real-world temporal patterns, the actual generation of syllables undergoes variations of rhythm. Proprioception, as viewed in GPNs, provides a solution to this problem, by sending a feedback to the lexical motor plan as soon as a phonetic unit has been successfully uttered. Whereas ANNs as well as psychological models implement a single type of signal (activation) for conveying both low and high levels information, GPNs provide a dynamic "threshold decrease" for high-level information to influence lower levels, while the opposite influence is handled by activation signals.

As shown in the previous sections, and in agreement with the *two-step process* model, the production of a word is triggered by a meaning-related signal. However, the corresponding threshold decrease is not effective without a basic activation of the phonological level (spontaneous activation), nor the occurrence of a series of propri-

oceptive stimuli. The syntactic module itself waits for lexical feedback before triggering the next word class to be instantiated by the next word in the string.

To summarize, in the field of language production, the possible contributions of GPNs to the "spreading activation" approach is twofold:

- A dialog between two types of signals originating respectively from low-level and high-level information.
- A never-ending learning procedure that incorporates new pieces of knowledge "in context", and therefore without necessary supervision; this involves a central unit that allows a given module to temporarily switch to the learning mode through an increase of thresholds.

5.2 Comparison of the Three Hypotheses

The aforementioned hypotheses may together impede the production of a target word. If the model is correct and if you'd like to avoid the unpleasant TOT-experience, then you'd better not be depressed (H3), only utter words that you are familiar with in general (H1), including in the current situation (H2).

Not all these explanations have the same status, though. The following may clarify the part played by each one of them, by underlining that basically only two coincident factors determine access to a target word:

- Activations: general spontaneous activity fed by proprioceptive stimuli (syllables) along the path.

- Decision thresholds: initial resting level of the pathway cells, decreased by signals conveying the semantic and syntactic current context.

Starting from their initial state, these two factors are modified in the course of processing. Once the thresholds have been lowered along the target pathway, the proprioceptive stimuli occur one after the other to guide the spontaneous propagation until the end of the path. One may note that there is another possible hypothesis to account for the TOT phenomenon: the lack of proprioception, not considered here since it would concern the entire lexicon rather than just the target-word. Likewise, the depressed spontaneous flow is not restricted to one particular target word.

The main question then is: how to deal with or how to compensate for the TOT problem?

A lack of internal spontaneous flow may find a pharmacological answer, not specific to the production of a target word. This would in addition require specific training. Once retrieved, repetitions of a target word would 'decrease its basic response thresholds'. Using this word in various contexts and moods would extend the number of links between its 'associated pathway' and conceptual representations, thus increasing its availability for subsequent context-driven, *two-step* retrievals.

6 Conclusions and Perspective

One of the most amazing problems people encounter in language production is their failure to access a word they are certain to know. That they have memorized the word

can easily be shown (they produced the word in the past, they are able to recognize it without mistake and immediately in a list of words, or they may produce it later during the day); yet, what accounts for their frustration is the fact that they cannot access the word when needed mostly, now.

While the metaphor of the Tip-of-the-Tongue seems self-explanatory and attractive, it is also misleading, if not a misnomer. Indeed, those being in this state have the impression that the word they are looking for has made it all the way from the mind to the mouth, or close to it, since it got stuck (or blocked) at the very last moment, when it reached the tip of the tongue. Of course, what happens in reality is different in kind, occurring at a different, deeper and far more central place, the brain.

As other dysfunctions of the brain machinery, the TOT effect may reveal basic mechanisms and inner organization of the involved structures. Sometimes considered as a type of "speech error", this phenomenon may better be described as a kind of word blockage, impeding fluency or access to the word to be inserted in a particular point of the chain, i.e. host sentence.

The reason generally given to explain why a lexeme could not be uttered at the right moment is lack of energy of the word's internal representation: the needed activation threshold could not be reached, as it may happen for a rare word. We offer other explanations in order to account for a subset of TOT symptoms. More precisely, we suggested two specific impairments of the GPN production mechanisms, namely: weak decrease of propagation thresholds and depressed spontaneous flow of activity.

These features remain to be studied with the same computer simulation, in experiments involving a large set of words of known frequencies and emotional values.

Comparisons with other models addressing the TOT question, such as the "two-stage" lexical access [17], may be carried out.

Another TOT feature that we plan to investigate is: "delayed retrieval". The target word pops up, but long after having been consciously searched for, and too late to be inserted in the specific slot reserved for it. For this goal to be met, a serial retrieval process is to be implemented, decreasing slightly, one after the other, the response thresholds of the lexical candidates. The word pathway whose thresholds has been decreased the most – but possibly not enough to make it at a given moment – would then get a better chance to be retrieved, finally.

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