WHAT IF LANGUAGE IS LEARNED BY BRAIN CELLS AND BRAIN CELLS DO NOT MOVE?

Eleni Koutsomitopoulou
Georgetown University

"...When people say the mental is the neurophysiological at a higher level, they're being radically unscientific... The belief that neurophysiology is implicated in these things could be true, but we have very little evidence for it. So, it's just a kind of hope; look around and you see neurons; maybe they're implicated." (Chomsky, N. Language and Thought [1993] 1997:85)

ABSTRACT.[1] Despite Chomsky's claims that generative grammar offers a "new understanding of the computational systems of the mind/brain" (Chomsky 1997: 52), generative grammar is not interested in the investigation of the biological foundations of language. Neurologists pose the question: how is language generated in the brain? And linguists wonder: what is the "natural" explanation of the various linguistic phenomena? Adaptive Resonance Theory (Grossberg 1972 et seq.) resolves a big part of the puzzle. The aim of this paper is to review and exemplify the basic claims of Adaptive Grammar (Loritz, in press) with examples drawn from Modern Greek and English.

1. A QUICK REVIEW OF ADAPTIVE GRAMMAR (AG) A primary assumption of the adaptive evolutionary explanation of language is that minimal dipole anatomies (or "primitive combinations of small numbers of neuronal synapses" (Loritz in press) can explain metathesis at the phonological as well as the morphological levels of language. Inhibition and excitation are the results of on-center off-surround neuronal dipole anatomies. These parallel rhythm generators can adequately explain spoonerisms as well as permutations in syntactic structures[2] and challenge generative linguists' hypothesis of syntactic movement. In the brain there are only activated patterns that may redistribute themselves, i.e. resonate in short-term memory (STM). This parallel brain activity is highly competitive and selects among lexical items, all of which bear potentially the same long-term memory (LTM) predisposition to appear in a specific location in a serial, syntactic lexical chain[3].

The context drives this potential distribution of lexical items when a sentence is uttered. The context gives rise to a specific topic (and the ordering of the sub-topics) in discourse. Thus, the principle of relevance (Grice's 1975, Sperber and

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[1] I am grateful to Prof. Donald Loritz for his valuable comments and insights on previous versions of this paper. A detailed account of Adaptive Grammar is now in press (Loritz, D. *Evolution, Brain and Language*, Oxford University Press).

[2] Following Selkirk 1984 (*Phonology and Syntax: The relation between Sound and Structure*, MIT Press) and her metrical grid theory of stress, which introduces (for example) a rhythmic nonsyntactic approach to the basic phonology of English function words, Adaptive Grammar is emphasizing the notion of an antipodal morphology and a bilateral rhythm generator.

[3] We may consider an exception here: Although all STM resonances are equally "strong" and transient, LTM relations, for example verbal case roles, may be stronger and, in fact, be activated faster. Rhythmic excitatory and inhibitory processes govern the activation of any lexical item. Context-sensitive (and short-term memory traced) topicality is the filter for the final output.

Wilson 1995 [1986]) is decisive in this competitive process of lexical selection. Although the contextual factor is primarily located in the surrounding environment, or in the surrounding discourse, adaptive grammar focuses on "the internal, cognitive, STM resonance" (Loritz in press): the most active STM resonance in a conversational turn constitutes the cognitive context of the discourse. Studies of primacy and recency effects in language recognition support the hypothesis that the first and the last items in a sequence can be most easily recalled. It is then explicable why old information (often referred to as "topic") is offered first in an utterance, while new information usually comes later in discourse. The notion of *topicality,* cognitively defined, is crucial in adaptive grammar.

Adaptive Grammar accounts for language learning as an ongoing, lifetime adaptive process rather than as a rigid alignment with some presupposed transformational rules, principles or constraints. In this theoretical framework the levels of linguistic analysis are redefined on the basis of a "primacy gradient" for phonological seriality and a "self-similar analog" of it for syntactic seriality (Loritz in press). No movement is necessary.

2. SUBJECT-TOPIC PRIMACY[4]: Consider the acceptability of the alternate answers to the questions below:

(1). - Pjan filise o Janis?
   '*Who did John kiss?'*
  a) - O   Janis filise   ti   Maria
     art-masc.nom John kissed-3S art-fem.acc Mary
    '*John kissed Mary'*
  b) - *Ti   Maria *ti*   filise   o   Janis
     art-fem.acc.   Mary clitic-fem.acc. kissed-3S art-masc-nom John
    '*John kissed Mary'*

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[4] Greenberg's Universal 6 (1966: 79) that languages with dominant VSO "have SVO as an alternative" and Lehmann's indication of the "profound SO unity" (Lehmann, W.P. 1978. 'Conclusion: Toward an understanding of the profound unity underlying languages'. Syntactic Typology: Studies in the Phenomenology of Language. Austin, TX: University of Texas Press, 342-395) have been tested in MG as well. Philippaki-Warburton, (1982, "Provlimata sxetika me ti seira ton oron stis ellinikes protaseis" (Problems regarding the word order in Greek sentences), *Glossologia* 1, 99-107 and 1983, "I simasia tis seiras RYA sta Nea Ellinika" (The meaning of the VSO order in Modern Greek) in *Meletes gia tin Elliniki Glossa,* Athens: Kirjakides, and 1985 "Word order in Modern Greek" *Transactions of the Philological Society*, 113-43, and Joseph & Philippaki-Warburton 1987, Modern Greek London: Croom Helm) claims that the primary word order in MG is VSO, while Drachman (1985, 'Language Universals. The Two Approaches' Studia Linguistica Diachronica et Sychronica. Amsterdam: Pieper-Stickel.) agrees with Greenberg (1966:75) that MG is a SVO language, but reduces the problem to a transformational explanation of verb fronting and subject-verb inversion. Horrocks (1983, 'The order of constituents in Modern Greek' Order, Concord and Constituency, Gazdar Gerald, Ewan Klein and Geoffrey Pullum (eds), 95-111, Dordrecht, Holland: Foris.) accepts both SVO or VSO as the basic word orders in MG. Modern Greek is considered a SVO language by Greenberg (1966), and this opinion seems to be prevailing. Adaptive Grammar is offering an account for the universal subject primacy in the languages of the world.

The reason why (1b) is unacceptable in the context of the specific question is that the object has been "topicalized", and the presence of the clitic before the verb, has made the verb a prevailing new information, whereas in the specific context the verb is not the constituent under question. On the other hand, (1a), which is a successful answer, offers the new information (*Maria*) in the end of the sentence in an unmarked (nonemphatic) way. Emphatic structures with the appropriate contrastive stress, and focus on the suitable elements, may also successfully answer the above question. For example:

(2). - Pjan filise o Janis?
　'*Who did John kiss?'*
　a) -**Ti Maria**　　　filise　　o Janis
　art-fem.acc.　Mary kissed-3S art-masc.nom　John
　　'*John kissed **Mary**'*
　b) -O Janis　　　**ti Maria**　　filise
　art-masc.nom　John art-fem.acc.　Mary　kissed-3S
　　'*John **Mary** kissed'*　　　　　　　　etc.

The above emphatic structures only mark a shift of the topical elements in the discourse. From the point of view of Adaptive Grammar "such "topicalized" sentences do not reflect topicality so much as *change-of-topicality*." (Loritz in press). Topic in AG is the "old information" in a sentence, which is preserved in a context or series of utterances, and presents a universal syntactic primacy effect[5]. There is always a topic slot in a sentence and its value depends on the specific discourse context. Adaptive Grammar explains this slot, as the first element in the "topic gradient", a resonant neural activation ordering which adapts in STM to the pragmatic demands of the communicative environment, and which is the linguistic product of a series of adaptations of fundamental vertebrate neural design.

3. Basic Sentence Generation[6]: The Nominal Topic And The Verbal Relation Gradients. If Greenberg's (1966) hypothesis of the universal subject precedence is right, Adaptive Grammar is attempting to account for it. Although agreement,

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[5] A large number of scholars (often from different Schools) have attempted to offer a definition of the notion of "topic" (for ex. Chafe 1970, Dik 1980, Prince 1981 etc.). Adaptive Grammar adopts the sociolinguistic (and pragmatic) notion of "old information", but it claims that a neurologically founded theory of language may account for such a basic discourse unit as a sentence (in contrast to conversation and intersentential relations). Thus. although it has been broadly recognized that "topic" is the most salient part of given information, little has been said about its in-sentence generation and its relation to the other sentence constituents. Adaptive Grammar claims to have developed an intrasentential syntactic account of the notion of "topic" (Loritz in press 162).

[6] This sentence formation level is based on five preceding levels of morphophonology: "*phrase, word, foot, syllable, and phone sets" (Loritz in press 151).* The phrase is organized into words. Each word into feet, each with a *downbeat* and an *offbeat*. Each beat consists of one or several syllables, and each syllable may be subdivided into two phone sets: consonant(s) and vowel(s) or, else, *onset* and *rhyme.*

nominative case, agency and topicality are considered to be the basic features of a subject, it seems that only the latter is a steadily common feature shared by the subjects of the languages of the world. Moreover, in order for a sentence to be generated, a subject has to be related to a verbal constituent. In terms of ART, a rhythmic dipole generates sentences consisted of a downbeat nominal topic gradient and an offbeat verbal relation gradient. Consider the following example (from Loritz in press):

(3) Prof. Plum killed Mrs. White in the hall with a knife

The nominal elements (*Plum, White, hall, knife*) comprise the topic gradient of this sentence. STM arrows indicate that the topic gradient T is contextual and temporary. The verb and its case roles (location and instrument) are activated in the verbal gradient. LTM arrows indicate that the case roles are expected, "primed"[7] relations of the specific activated verb. An alternation between the topic and the verbal gradients generates the sentence. In the figure below we see how this topic-relation dipole rebounds for the generation of (3):
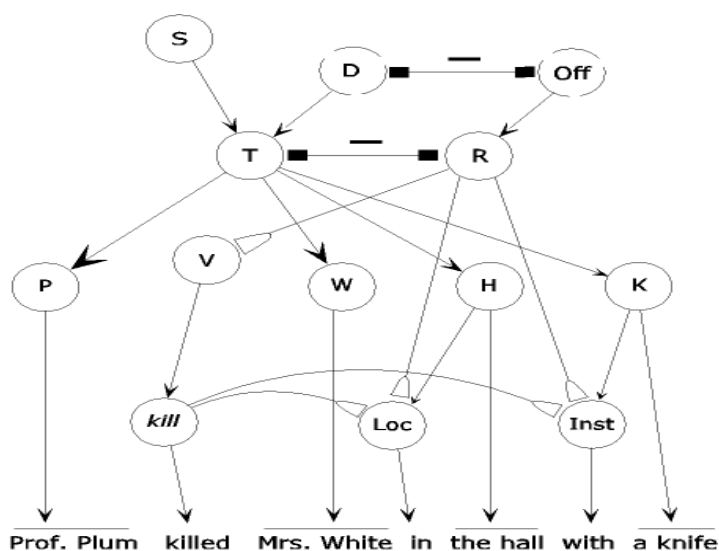

Figure 1: A nominal topic gradient and a verbal relation gradient combine rhythmically to generate sentence (3)

The T pole is activated first in the utterance of sentence S. The topic relation dipole alternates with the downbeat-offbeat "foot" dipole (antipodal morphology)[8]. The topic gradient (P, W, H, K) is activated first in STM, and then

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[7] The fact that a verb and its case roles are learned in LTM causes certain "priming effects". For example, in psycholinguistic studies subjects may recognize the word *knife* more quickly after having first been "primed" by hearing or seeing the word *kill* or *murder* (for example, Swinney 1982; Small *et al.* 1988).

[8] It is important to note that the presence of more than one foot on each pole (of the topic and relation dipole) does not impede the rebounding process in a sentence generation, as "several feet may occur on each pole" (Loritz in press 167). Figure 1, however, for simplicity does not show

deactivated via cerebellar inhibition (Loritz in press, Cohen and Grossberg 1986). As T is deactivated, the dipole rebounds and R becomes activated. Loc and Inst are activated by LTM primacy (as learned case roles of the verb). After *killed* becomes the output, it is deactivated, the dipole rebounds, and *Mrs. White*, the next most-active nominal element in the topic gradient is activated. As the topic is deactivated, Loc and Inst are equally activated by R and output. In the LTM verbal gradient either of those can be output next, but following a contextual topic primacy ordering *H>K*, Loc is output first and then Inst (*in > with)*. The dipole will keep on alternating until all the nominal elements have been activated. So, after *Mrs. White*, *the hall* is output (the locative *in* in the verbal gradient has been previously activated by R). Finally, the instrument *with* is output as the dipole deactivates the topic *hall* and activates the instrument in the verbal gradient. The last rebound activates the last topical element, *a knife*.

According to the preceding analysis, the topic gradient is the currently most activated referential subnetwork in the cortex. In discourse a persistent STM activation will drive the topic to prominence among competing sentence elements. In the unmarked sentences of the languages of the world, the topic is the first "propositional"[9] nominal element of a sentence.

4. TOPIC GRADIENT IN DATIVE "MOVEMENT":

MG affirmative sentences with direct and indirect objects, which are explicitly presented as NPs (instead of as clitic proforms), present a flexible word order. In addition, the indirect object of a transitive verb like *give* will be an NP in genitive case, which can alternate with a PP consisting of the dummy preposition "se" (to) and the NP in accusative case:

(4)   Edosa   ston/tu   Jani ena doro
        give-past-I to+art.masc.acc./art.masc.gen. John a   present
        'I gave John a present'

(5)   Edosa   ena doro   ston/tu   Jani
        give-past-I   a present   to+art.masc.acc./art.masc.gen. John
        'I gave a present to John'

In languages like MG that have rich overt morphological case-marking every overt NP has case whether it's a verb argument or an adverbial. The latest version of the Standard Generative Theory, the Minimalist Program Chomsky 1995), has elaborated a Case Theory based on the notions of "dative movement", Case Filter, abstract "Case Features", and "feature-checking", in order to account for "Case-assignment". However, it still remains a question how these NPs (loosely described as the "complements of prepositions") will be case-checked

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how '*Prof.* Plum' and '*Mrs.* White', '*the* hall' and 'a knife' derive.

[9] For example in (3) the nominal elements of *location* and *instrument* are not propositional case arguments of *kill*, while semantic cases like *actor* and *patient* are considered to be the essential semantic organization arguments of a transitive verb like *kill*. *Location and instrument* are usually optional, thus "nonpropositional" arguments (adjuncts). However, nonpropositional elements may still be promoted to topicality in marked contexts.

and how they will eliminate their "abstract Case-features". In all the other cases, NPs have their theta-roles licensed in the "base position" (the so-called Deep Structure), and their cases also licensed first in DS, and then --if the case is not licensed in the DS-- the NP must "move" to a Spec position of some "functional head" where the case is licensed. Now the problem is reduced to the initiation of a "Spec-of-PP" position. In addition, as shown in (4) and (5) above, these PPs, in languages like MG, may alternate with NPs in genitive case, while still being core arguments of the verb in a sentence. How will such cases be "licensed"?

In Adaptive Grammar there is no need for a movement-transformation to relate the two different forms (PP with NP in accusative vs. NP in genitive). Each one is explained in terms of neural activation and a topic gradient, similar to the one described for sentence generation (figure 1 above). Following Fillmore and its Case Grammar, (1968), Adaptive Grammar accepts that "there is a correlation between such grammatical categories as *nominative* (subject), *accusative* (direct object), and *dative* (indirect object) and such semantic categories as *actor*, *object*, and *donor/recipient*." (Loritz in press) The MG genitive case is --like the English dative-- the case of the indirect object (and it will be activated in the nominal topic gradient[10]). When it is substituted by a PP, it will be generated in the verbal relation gradient just like Loc and Inst in sentence (3) above.

The so-called "dative movement" can be explained in terms of context, topics and subtopics. Consider the following examples in English:

(6) The judge issued a subpoena to John
(7) The judge issued John a subpoena

Instead of attempting to relate them through a movement-transformation, Adaptive Grammar will put the sentences in their contexts and see how the topic gradient works in each case:

Context: The judge didn't issue many subpoenas. (But,)
  (6) The judge issued a subpoena to John.
  (7a) * The judge issued John a subpoena.
  (7b) The judge issued **John** a subpoena

With contrastive stress on *John* (as in 7b), (7a) becomes acceptable. In this context *the judge* is the topic of the discourse and *subpoena* is the new information. In (6) *subpoena* has become a secondary topic, while new information is introduced: *to John*. (7a) is unacceptable in this context, because it introduces new information in (secondary) topic position (*issued John a subpoena*). In a different context, (7) may be acceptable but not (6):

Context: The judge heard the testimony regarding John. (And,)

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[10] In Adaptive Grammar, grammatical morphemes are considered to resonate in the *relational system*. This system does not affect metaphesis (as these morphemes are universally unstressed), but it is "the grammatical glue that holds sentences together" (Loritz in press).

(6) The judge issued John a subpoena.
(7) * The judge issued a subpoena to John.

In this context, *John* is the new information, which may become the secondary topic as in (6). (7) introduces the new information *subpoena* before the secondary topic, which is unacceptable.

5. TOPICALIZATION AND PASSIVES:

According to Adaptive Grammar, there is no transformational relation between the passive and active constructions. Each one derives from a process of lexical/semantic distribution of items in the appropriate context. Following Fillmore's case grammar (1968) and putting the semantic deep structure and the propositional case arguments in their context and adjoining them to the notion of topicality, Adaptive Grammar can account for the passives without a need to resort to transformational rules. Passive is used to adjust syntax to topicality. The use of passive is based on the same primacy effect that works at the phonological and morphological level of linguistic analysis. Consider the variations of the sentence below:

(8)   ? I   Maria xtipithike   apo   to   Janni
      art.fem.nom. Mary hit-pass.3S   by   art.masc.acc. John
      '*Mary was hit by John*'
(9)   O   Janis xtipise ti   Maria
      art.masc.nom. John hit-act.3S art.fem.acc. Mary
      '*John   hit Mary*'

The semantic structure of the MG verb *xtipo* requires a "victim", the patient. (8) is not readily acceptable unless *Mary* is resonant in STM as the previously-established topic of discourse. (9) is the successful, unmarked version of (8), where the agent is in topic gradient and the new information is given with the VP that follows (*xtipise ti Maria*). Contrastive stress would focalize the agent should it be the case that the identity of the agent is the new information in (10):

(10) O **Janis** xtipise ti Maria
     '***John** hit Mary*'

Adaptive Grammar considers all "fronting", "focusing", and "topicalizing" of the patient or theme to be manifestations of an underlying topic gradient. The most resonant—hence most topical— element in the speaker's STM is uttered first. Passive constructions mainly serve the re-arrangement of topic and new information in a sentence. As we have seen, MG supports this claim that topicality and context dependency are crucial factors for the acceptability of passive sentences.

6. Particle movement[11]

Another case of the same topic gradient effects is that of the so called "particle movement". In English, both the context-free sentences below may be felicitous:

(11) Mary made up *a story*
(12) Mary made a story *up*

However, given a specific pre-established discourse topic, only one of those is pragmatically acceptable:

Context: The children wanted Mary to tell a story, (so)
(11) *Mary made up a story
(12) Mary made a story up

7. Pronouns And Traces

Adaptive Grammar accounts for clitics, pronouns and other pro-forms on the same basis of cerebellar[12] inhibition and bottom-up rebounds. Pronouns (and other proforms) are generated through a rhythmical activation and rebounding of a nominal topic gradient and a verbal relation gradient, a process similar to the one described above in sentence generation (figure 1). Consider the following examples:

(13)   O Nikos   xtenizi   ton Mario
        '*Nick* [brush-his-hair]-active-3S Mario'
(14)   -O Nikos xtenizi   afton
         '*Nick*   [brush-his-hair]-active-3S *him*'
(15)   -O Nikos   xtenizi   ton eafto tou
         '*Nick*   [brush-his-hair]-active-3S *himself*'
(16) *O Nikos   xtenizi   ton Niko
        '*Nick*   [brush-his-hair]-pass./reflex.3S *Nick*'

Once (13) is uttered, the cerebral plan for its stress-bearing object (*Mario*) becomes deperseverated, and the competing cerebral motor plans for the personal pronoun (14) or the reflexive pronoun (15) are disinhibited. In figure 2 below the topic-relation gradient has been simplified:

In (a) we describe sentence (13). After (a) is uttered, *Mario* is deperseverated and in (b) *O Nikos xtenizi afton* (14) is expressed. As *Mario* is not the primary topic, it is not possible for the motor plan for *ton eafto tu* (himself) to be activated in (b). In (c) the generation of sentences (16) and (15) is described.

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[11] In MG there are no phrasal verbs as in English, and prepositions come steadily before the NP or the Adverb that they modify. When a PP modifies a verb, it may be in (virtually) any possible order in a sentence (before or after the verb), but always as a inseparable unit.

[12] The motor plan of a sentence is its rhythmic alternation of downbeat-offbeat patterns of syllabic structure, a self-similar analog of the neural succession of excitatory and inhibitory activation.

Nikos is activated and then deperseverated and *afton* (him) and *ton eafto tu* (himself) are ready to be activated. Note that the personal pronoun may be the more frequent, but the reflexive is re-activated by the primary topic (the subject of the sentence, i.e. *Nikos*).
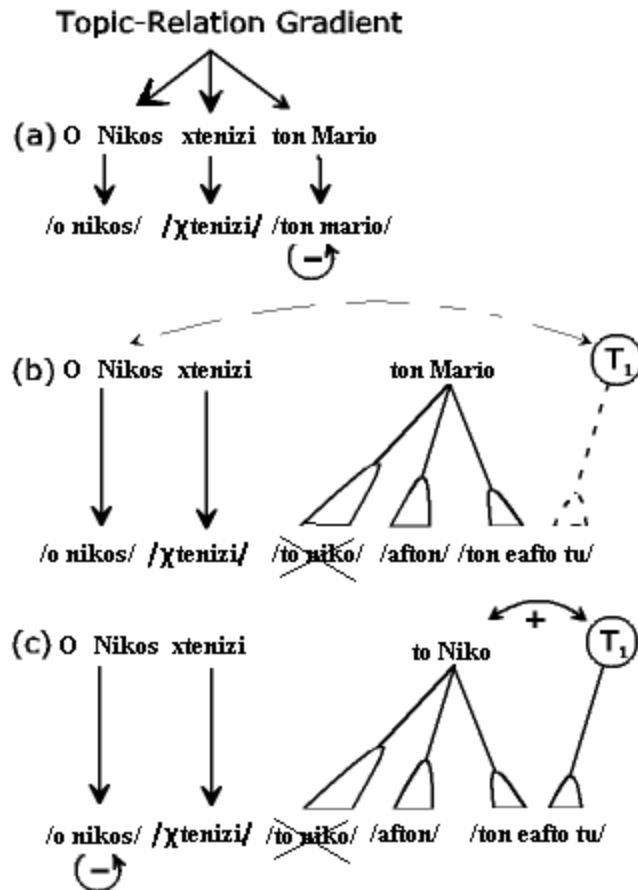

Figure 2: Simple Pronominalization

The generative notion of "traces" is analyzed in Adaptive Grammar as a "'null pronoun', the completely inhibited motor plan of its antecendent." (Loritz, in press) Consequently, ART is not explaining syntax with movement-related rules, but rather through dynamic neural patterns, which become activated depending the context and the natural rule of topicality.

8. THE SCOPE OF NEGATION

(17) John didn't read his book yesterday
(18) John didn't (NEG read his book yesterday)
(19) John didn't (NEG *read*) his book yesterday
(20) John didn't read (NEG *his book*) yesterday
(21) John didn't read his book (NEG yesterday)

While (18) reads the entire verb phrase *read his book yesterday* as being within the scope of negation, it is more likely that the preferred reading is that John **did** read the book, although he just didn't read it **yesterday**. (19) and (20) are possible readings, but only with contrastive stress on the italicized words. The preferred reading is that *yesterday* is being negated, as in (21). Adaptive Grammar explains the negation of the rightmost element in sentence (Ross 1978) as "a burst of nonspecific arousal"[13] and rebound of the newest information in sentence. R*ead, his book* and *yesterday* are all potential scopes for negation, but it is at the end of the sentence where NEG is applied with global effects.

The same contextual effects described in "dative movement" and "particle movement" above, are also met in negation. Sentences (17) to (21) above are context-free, but AG also accounts for negation in discourse context. Consider the examples below:

(22)   -Did John read his book yesterday?
(23)   -*No*, John didn't read his book yesterday

where the *No* immediately follows, rebounds, and negates (22)— and especially the new information in (22), *yesterday*.

9. QUESTIONS, EXTRACTION AND BARRIERS

In the framework of ART, complex sentences with embedded subordinate clauses are not "transformed" to questions through a series of postulated processes like extraction, movement and barriers, but rather through a natural process of rhythmical activation (dipole rebounds) and cerebellar deperseveration of the elements of the sentence. For example:

(24) Is the man who is dancing singing a song?

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[13] The absence of contextual, specific arousal of the new information causes global rebounds in the case of negation. Some theories of metaphor have explained the impact of metaphorical utterances in a similar way.
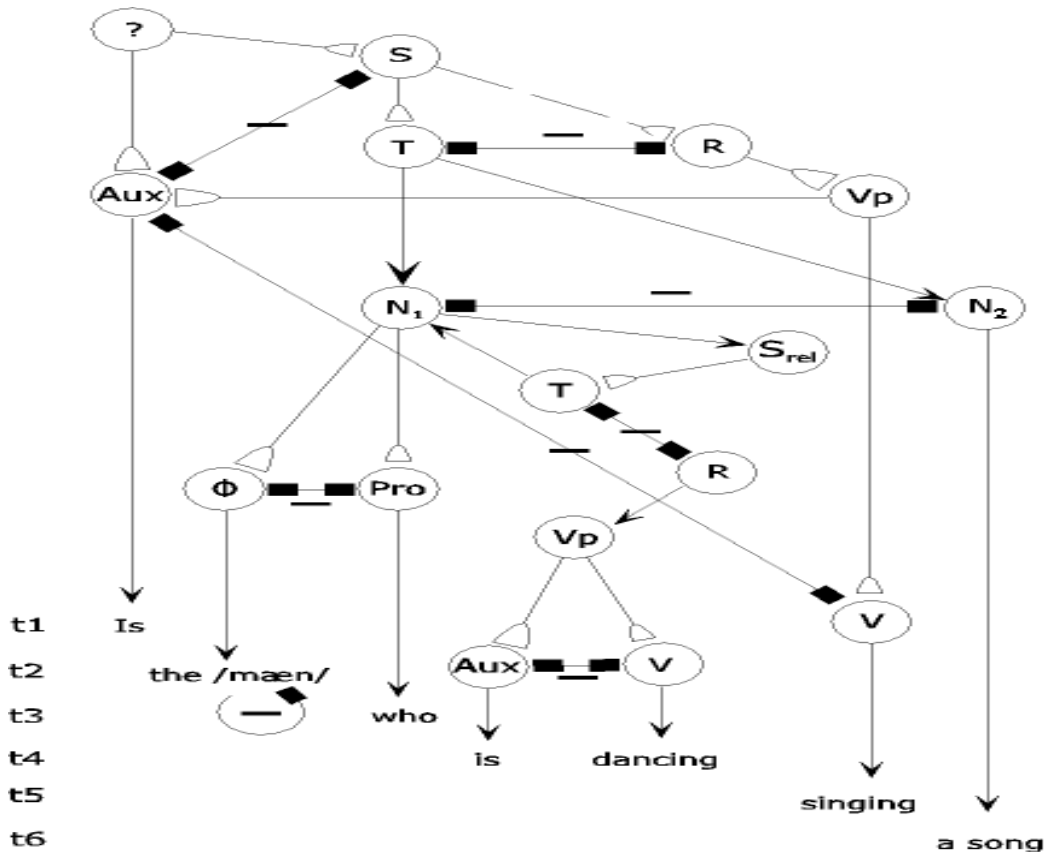
Figure 3: *Generation of questions and simple relative clauses.*

The first nominal element of the sentence (N_1) is its topic (*man*). The phonological form *F,* or a *Pro* are the two possible realizations of a nominal element. At t2 the instance of *man* (*i.e.*, the phonological form /mæn/) is deperseverated. Then it is the turn of the relative clause S_{rel} to be activated. S_{rel} (re)activates topic (*T),* which -in this case- is again the nominal element *man.* Since *F* has been deperseverated, *Pro* now becomes active, and *who* is output at t_3. At t_4 the dipole switches to the verbal relation gradient *R*. *Aux* and *V* are activated and *is dancing* is output. At *t5* *Vp, S_{rel},* and N_1 have been deperseverated. The "top level" relation dipole rebounds, and the main clause's *Vp* is now activated. *Aux,* however, has already been performed and deactivated, so the *V singing* is output at t_5. Finally, the top level *T/R* dipole rebounds back to *T*. The nominal element N_2 is activated and *a song* is output at t_6.

10. CONCLUSIONS

In this paper we offered a brief overview of some of the basic syntactic phenomena that can be explained in the framework of Adaptive Grammar. The universal subject primacy in the languages of the world calls for a cognitive

(re)evaluation of the notion of "topic" (or "old information") and its contextual function. If language is the serial output of a parallel process, then "movement" is an artificial way to account for language, and Adaptive Grammar can more parsimoniously account for syntax with a neural "topic, a resonant neural activation-ordering capable of adapting to the pragmatic demands of each discourse. In this framework, language shows itself to be an obvious –if complex-- self-similar adaptation from early vertebrate neural design. With examples drawn from English and Modern Greek we have shown how "dative movement", "wh-movement", passive transformation, particle movement, pronominalization and traces as well as the scope of negation can be explained in terms of minimal anatomies and a topic gradient instantiated in short-term memory.

It would be interesting to further investigate the expansion of AG's phonological and syntactic analysis to a lexical-semantic account of related phenomena. For example, findings about Specific Language Impairment (Gopnik 1990, 1992, 1994, Gopnik and Crago 1991, Ullman and Gopnik in press, Dalalakis 1994) are posing very interesting questions about the language learning process. Simultaneously, studies of various agreement errors in the language of SLI subjects, (Clahsen 1989, and Rice and Oetting 1993) and the affected subjects' difficulty with past tense, anaphoric pronouns, and tense consistency in narratives, have been interpreted to support the hypothesis that "associative memory" and "rule-governed memory" (Pinker 1991, Ullman et al. 1997) constitute the basis of the human cognitive-linguistic mechanism. Adaptive promises an alternative account of the nature of such "rules" and "associations" in the development of the linguistic faculty in the brain. Under AG, language acquisition is regarded as an ongoing adaptive reorganization of neural resonances. Beyond this, there remains the challenge of accounting in detail for the (presumed) function of a neural semantic network.

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