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The Terraced Labyrinth Framework For Modelling Language Emergence

Part One - The Internal Model

Stephen Shucart

Introduction

The Terraced Labyrinth model of language and language learning originated in the field of Evolutionary Computation as an alternative to the standard fitness landscape. Language evolution and acquisition, along with other dynamical systems, exhibit epochal evolution - "…behavior in which long periods of stasis in an evolving population are punctuated by sudden bursts of change." (Crutchfield and van Nimwegen, 1999,p. 1) The Terraced Labyrinth differs from the usual fitness landscape in that it utilizes a subbasin and portal architecture to model emergence as a phase transition between levels within a multidimensional framework. An understanding of the separation of scale is necessary to comprehend the place of Second Language Acquisition（SLA）in the current model. Acquisition is a form of emergence, a phenomenon that seems to have a fractal presence in our space-time continuum. Painted in broad strokes, it stretches from the Big Bang instant when Planck-length superstrings began to sing out existence in 11 dimensional Calabi-Yau shapes（Green, 1999), through the coalescence of hydrogen and helium, the flash of nuclear fusion, the formation of solar systems, and the jump from inorganic to organic. Narrowing the focus to our earthly biosphere, life emerged, and adapted under the random variables of gravity, atmospheric composition, and catastrophic collisions with cosmic debris to the tune of epochal evolution. Mammalian, primate then hominid minds coevolved with social systems through the Peircian levels of Iconic, Indexical, and Symbolic consciousness until reaching today's post-modern level of language and culture (Deacon, 1992; Mithen, 1995; Noble and Davidson, 1996). Sausaurre referred to *langue* and *parole*, Chomsky discussed *performance* and *competence*, and Hymes talked of *linguistic competence* versus *communicative competence*. This paper, however, will focus on language acquisition at two levels, Part 1 will introduce the Terraced Labyrinth, and will introduce the neurolinguistics and psycholinguistics of the internal model, while Part 2, which will be presented later, will concern itself with an external model of sociolinguistics. The reader should keep in mind that the two sections do not refer to a linear progression, one does not follow the other, rather they are nonlinear and simultaneous, merely separated by the phase transition of emergence and scale.

1　Terraced Labyrinth - The Internal Model

1.1　Language, Evolution, and the Human Mind

The first concepts that need to be clarified

in this model of language acquisition are *genotype* and *phenotype*. Genotype is the code, the DNA, the basic set of rules for an opera ting system. The phenotype is what emerges when those rules are followed. The phenotype is susceptible to outside variables and random mutation. In the case of human language, there is no separate genotype in hominid DNA which corresponds to language, rather, the genotype which generates the organ called the human brain co-evolved with language as we made the emergent step from *Homo Erectus* to *Homo Sapiens* (Deacon, 1992). Exaptation describes a structure that emerges in evolution before the function it now performs. Stephen J. Gould (1991) calls the human brain ' the best available case for predominant exaptation'. There has been a consistent and identifiable pattern of increased brain size for the past 3.5 million years. Brain casts from two million-year-old hominid fossils show a region corresponding to Broca's Area, one of the sections of the modern brain devoted to language processing (Noble and Davidson, 1996).

Language rules do not have a physical existence in the structure of the human brain. Language rules exist in the minds of linguists who take random examples of natural language production and dissect it. In the spirit of Western, reductionist science, they kill a piece of living language, mount it on a board and cut it into pieces. They then examine these individual pieces under their microscopes, and write learned papers on rules that constrict the patterns that these pieces can form. This linear science is correct as far as it goes, but it fails to take into consideration the nonlinear, living whole that emerges from the interactions between the connected parts.

Such diverse scientists as the biologist Terrence Deacon (1992), the psychologists Donald Merlin (1991), and William Noble (1996), and the archaeologists Iain Davidson (1996) and Steven Mithen (1995) all use the cognitive system devised by the American philosopher Charles Peirce in their models of the co-evolution of language and the modern mind. They talk of the three levels: Iconic, Indexical, and Symbolic, as the stages through which language and mind progress to reach our current level of cognition. Stephen J. Gould and Nils Eldredge (1977) developed the concept of Punctuated Equilibrium to explain the lack of transitional forms in the fossil record. These emergent jumps from Iconic to Indexical to Symbolic seem to mirror external archaeological evidence that has become the accepted modification to the Neo-Darwinist model of evolution - gradual change and adaptation via the mechanisms of mutation and natural selection. The Terraced Labyrinth model explains the details underlying this epochal evolution.

1.2 Subbasins, Portals, and Constellations

Previous complexity-based models of language acquisition were based on the image of a Fitness Landscape. (Kauffman, 1995) But the Fitness Landscape model came from the field of evolutionary biology, and "patterns one sees in biology are not always found in other Complex Adaptive Systems." (Axelrod and Cohen, 1999) James Crutchfield and Eric van Nimwegen, who grounded their model in the fields of evolutionary computation and statistical dynamics, were also unsatisfied with the fitness landscape image:

> The evolutionary biologist Wright introduced the notion of "adaptive landscapes" to describe the (local) stochastic adaptation of populations to themselves and to the environmental fluctuations and constraints… The basic picture is that of a gradient-following dynamic moving over a "landscape" determined by fitness

"potential". In this view an evolving population stochastically crawls along a surface determined, perhaps dynamically, by the fitness of individuals, moving to peaks and very occasionally hopping across fitness "valleys" to nearby, and hopefully higher fitness peaks … the common interpretation of punctuated equilibria in evolving populations is that of a population being "stuck" on a local peak in a landscape, until a rare mutant crosses a valley of relatively low fitness to a higher peak. (Crutchfield and van Nimwegen, 1999)

1.3 First Language Acquisition in the Terraced Labyrinth

Rather than being a *tabula rasa*, a child's brain is a set of proto-modules with more than three times the number of neurons found in an adult. A process of Hebbian learning, environment variables, and cybernetic feedback, sculpt the brain architecture through Piagetian cognitive levels as it matures. The possible ways for this genotype-space to evolve are nearly infinite and that is why even identical twins, virtual clones, raised in the same household, become individuals and not exact duplicates of one another. This paper is only concerned with that fraction of genotype space which we shall refer to as language space, i.e. the near infinite way in which all possible languages, past and future, could evolve. Rather than the fitness peaks and valleys of the landscape, this version of language space 'decomposes into a set of neutral networks, or *subbasins* of approximately isofitness genotypes that are entangle with each other in a complicated fashion' (Crutchfield and van Nimwegen, 1999). Each subbasin can be considered to represent a single feature of the complex adaptive system (CAS) called language. The network of subbasins consists of both strongly and weakly connected sets, with those of equal fitness forming strongly connected subbasins.

Rather than being trapped on local optimum fitness peaks, as in the 'landscape' models, the learner drifts randomly through connected subbasins, and a balance between variables leads to a meta-stable state until a connection is found to a network of even higher fitness. Only short bursts of adaptation occur during an innovation, and then equilibrium is reestablished. The connections between the subbasins are referred to as portals, and long periods of stasis occur while the diffusion and search for a portal to a higher fitness level is carried out. Crutchfield and van Nimwegen describe it thus:

> … we shift our view away from the geographic metaphor of evolutionary adaptation "crawling" along a "landscape" to the view of a diffusion process constrained by the subbasin-portal architecture induced by degeneracies in the genotype-to-phenotype and phenotype-to-fitness mappings … it focuses on the *dynamics* of populations as they move through the subbasins to find portals to higher fitness. (Crutchfield and van Nimwegen, 1999)

The genotypes in the populations, or, in our framework, the different language subbasins, can be represented as bit-strings of a fixed length. A portal consists of a *constellation*, a subset of bits that is set to a particular configuration from which a new ability emerges. When the parameters of a specific constellation are set to specific values, the child moves through the portal to a higher-level subbasin and can be said to have now acquired that language pattern. A hierarchical tree is the easiest way to represent the constellations and their connections via

portals, and 'setting a constellation to a portal configuration leads one level up the tree' (Crutchfield and van Nimwegen, 1999).

We should perhaps note here that a Universal Language Tree - one constructed by overlaying all possible language trees, past, present, and future - must contain Chomsky's Universal Grammar (UG) as a sub-section. Such a universal Terraced Labyrinth would contain all possible human languages. If a path could not be traced through the tree to a particular feature, then that feature could not appear in any human language. If a path could not be traced through the tree connecting any two features, than those two features could not coexist in a single human language.

A Terraced Labyrinth model of first language acquisition alleviates the need to posit Chomsky's mysterious Language Acquisition Device - a black box to explain the innate knowledge a child would need in order to achieve such rapid fluency without the seemingly necessary exposure to an impossible quantity of comprehensible input. The subbasin and portal architecture of the Terraced Labyrinth explains the fixed stages of interlanguage through which a child progresses by setting the portal constellations. It also provides a model of a mechanism for the coevolution of the brain and language.

1.4 Second Language Acquisition in the Terraced Labyrinth

Learning a second language has both similarities and differences to a child's acquisition of its mother tongue. One of the most important features is the fact that fluency in the L1 is part of the genotype to acquire the L2 phenotype. Again, the best way to envision this hierarchical structure of subbasins and their connections via portals is as a tree. The tree-like form of the L1 and the L2 can all be thought of as part of a universal language tree. The nodes of the tree, both L1 and L2, represent subbasins of genotypes with equal fitness. For example, the indexical pronouns of the L1 could reside at the same level as those of the L2, even though some languages, like English, have only a single word for 'I', and others, like Japanese, can have many, depending on such variables as gender, age, and politeness. The complex interweaving of nodes and connections, branches and leaves of the L1 and L2, explains why sometimes the L1 can facilitate the acquisition of certain language structures and sometimes it can impede it. It all depends on how similar the constellation settings are.

Though the language tree as a whole is both nonlinear and multidimensional, the pattern of progress through the levels is linear. It is this one-dimensional strand of linearity that is most often abstracted and studied out of context in traditional linguistics. Interlanguage studies show a distinctive pattern. Acquisition order follows a set hierarchy across languages: stage 1: Case/ Word Order; stage 2: Singular Copula/ Singular Auxiliary/Plural Auxiliary/Progressive; Stage 3: Past Irregular /Possessive /Long Plural/ 3rd Person Singular; stage 4: have/-en, etc. (Dulay and Burt, 1975). But details of this acquisition change from student to student, depending on variables, such as modality, the propensity for a more aural or visual orientation; the environment, whether it is a classroom with students of a similar level or not; the quality and techniques of the teacher; and other external factors and their interrelationships which shall be covered in more detain in the next section. These factors contribute to the nonlinearity of acquisition.

The subbasin and portal architecture with its emphasis on constellation settings as the

mechanism for language emergence explains the importance of comprehensible input to second language acquisition. Supplying input with many examples of the correct settings for the hierarchical level of the subbasin that the student is exploring allows more opportunities for the portal settings to be discovered, language patterns to be abstracted, and progress to the next language level to be accomplished.

This model also provides a framework that differentiates 'learning' and 'acquisition'. Though the exact pathway varies between individuals, and the precise details of what input will trigger constellation setting cannot be predicted; the linear connection of the portal and subbasin architecture generally remains unbroken once it is established. Learning takes place on a separate branch of the overall tree and may not include many necessary portions of the language tree. The teacher or syllabus can dictate rote memorization of selected patterns, such as a random list of vocabulary words or the drilling of a grammar pattern out of the natural acquisition order. With enough practice the student can set the portal constellations and 'learn' the snippet of language well enough to pass a discrete point achievement test. But, since the patterns are not connected to the rest of the language tree, the learned lessons cannot be utilized automatically in a communicative situation and may be quickly forgotten. Of course, when that branch of the language tree is eventually connected to the trunk, those subbasins could be more easily acquired than completely new material.

2 Conclusion

Complexity-based frameworks for modeling language acquisition all offer more realistic pictures of this nonlinear, dynamic process than the traditional linear and reductionsist models favored by mainstream linguists. While these models are able to distill the patterns of language emergence and offer fresh insights from their various perspectives, they failed to include the multidimensional pattern of the hierarchical whole, especially across the major boundary between the mechanism of language emergence within an individual and the fractal jump in scale to language emergence in a social setting. By including these complexity-based frameworks in its subbasin, constellation setting, and portal architecture the Terraced labyrinth model eliminates these problems, as well as explaining the difference between learning and acquisition, the step-like pattern of punctuated equilibrium found in all language emergence, and the complexly entwined nature of the relationship between neurolinguistics, psycholinguistics and sociolinguistics

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