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# 34. Emergentism



The modern study of language can be viewed as the tale of two competing paradigms: Universal Grammar (UG) and Emergentism. These two paradigms assume fundamentally different positions on ten core issues: the scope of language, the uniqueness of recursion, rules vs. cues, the relevance of E-Language, the suddenness of the evolution of language, the genetic control of language, the idea that speech is special, critical periods for language learning, neurological modules for language, and the poverty of the stimulus during the language learning.

UG analyses emphasize explanations of language structure grounded on inborn principles specific to human language (Hauser et al. 2002), as expressed in recursive function theory (Chomsky 1963, 1976, 2010). In contrast, emergentist analyses are grounded on three core frameworks deriving from adaptive systems theory. The first is the Darwinian theory of evolution based on proliferation, competition, and selection. The second is the analysis of complex systems as structured hierarchically into levels, such that higher levels of complexity emerge from lower levels in ways not fully predictable from lower level properties. The third is the theory of timeframes that holds that processes on different levels are linked to very different timescales that mesh together through competition in the present. These three frameworks are not unique to linguistic analysis. In fact, they are fundamental to scientific investigation of all physical, biological, and social processes. In this paper, we will first describe how these frameworks apply to the study of language. Second, we will consider the relation between Emergentism and more specific linguistic frameworks, such as functionalism, cognitive linguistics, connectionism, embodied cognition, usage-based linguistics, and competition theory. Third, we will examine some of the specific mechanisms and structures involved in emergentist models. Fourth, we will survey the methods required for elaborating the theory of language emergence. Finally, we will contrast the Emergentist Program with the Minimalist Program of Universal Grammar in terms of their positions on the ten core issues mentioned above.

## 1. The three frameworks supporting Emergentism

In this section we will explain and illustrate the ways in which Emergentism relies on the theories of natural selection, complexity, and timeframes.

### 1.1. Natural selection and competition

Competition is fundamental to biological processes. Darwin (1859) showed how the evolution of the species emerges from the competition between organisms for survival and reproduction. The three basic principles Darwin identified are proliferation, competition, and selection. Proliferation generates variation through mutation and sexual recombination. Organisms with different compositions then compete for resources or rewards such as food, shelter, and the opportunity to reproduce. The outcome of competition is selection through which more adaptive organisms survive and less adaptive ones disappear.

The emergence of structures from proliferation, competition, and selection represents the basic source of change in all biological and social systems, including language. Economic analysis (Friedman 1953) has shown that free markets generate a wide variety of products, sellers, and buyers who then compete and cooperate to achieve optimal pricing and efficiency. In social systems, we can characterize the emergence and spread of new fashions, trends, and ideas through the theory of memetics (Mesoudi et al. 2006), which is closely modelled on evolutionary theory (D. Campbell 1960). In multicellular organisms, the immune system proliferates a multitude of antigens to compete with and defeat invading antibodies. Those antigens that match actual threats are replicated and those that do not are winnowed out. In all of these systems, from economics to the brain, development emerges from the mindless interaction of proliferation and competition without relying on any external master plan.

Emergentist approaches to language (MacWhinney 1999) also view language shape and language change as arising from the processes of proliferation and competition. For the organism as a whole, the fundamental functional pressure is to reproduce. For language, the overall functional pressure is to communicate. However, just as the genes are the basic units of biological proliferation and competition, the actual units of linguistic competition are the constructions, which are mappings between forms and functions. Functions include motives as diverse as identifying a referent (Silverstein 1976), expressing politeness (Helmbrecht 2013), expressing derision through imitation (Haiman in press), setting a temporal reference point (Smith 1991), coding exclusive disjunction (Ariel in press), placing presentational focus (Francis and Michaelis in press), shifting agential perspective (MacWhinney 2008c), inserting parenthetical material (Kaltenboeck and Heine, in press), and scores of others. All of these many functions are mapped onto forms using overlapping vocal, gestural, and prosodic constructions in a process of continual competition (MacWhinney 1987) during language use, learning, and change.

As MacWhinney et al. (1984: 128) noted, "the forms of natural languages are created, governed, constrained, acquired and used in the service of communicative functions". Bates and MacWhinney (1982) noted that this functionalist position can be dissected into three separate claims. The first is that language change across generations is determined by communicative function; the second is that language acquisition in the child is shaped by communicative function; and the third is that language form in real time conversations is controlled by communicative function. On all three levels, the facilitation of communicative function is viewed as depending on the availability of supporting neural mechanisms.

The handmaiden of competition is cooperation. As Bates and MacWhinney (1982) noted, humans have a great many ideas that they would love to express all at once. But language only allows us to say one thing at a time. One way in which language addresses this problem is by allowing motives to form coalitions. Bates and MacWhinney (1982) analysed the possible solutions to competition as: (1) peaceful coexistence, (2) divide-the-spoils, and (3) winner-take-all.

We can illustrate these solutions by looking at subject marking in English. In the unmarked active transitive clause, such as *the car hit the pole*, the subject (*the car*) expresses a coalition of motives including agency, perspective, givenness, and topicality. This construction represents peaceful coexistence or coalition between the motives, because they all point in the same direction. In the vast majority of cases, these motives do in fact co-occur yielding the active clause as the dominant form for transitive verbs. Peaceful coexistence depends on natural patterns of co-occurence in the real world. For example, the properties of solidity, boundary, and firmness tend to co-occur for objects. Similarly, in animals, properties such agency, movement, warmth, and directed attention all tend to cooccur.

When speakers of a language choose to emphasize one of the features in a peaceful coalition over others, the coalition can break down, precipitating a divide-the-spoils solution. For example, English uses the passive construction, as in *the pole was hit by a car*, as a way of dividing the spoils between the topic/perspective (*the pole*) and the agent (*a car*). In this case, the topic receives the prizes of subject position and agreement and the agent receives the "consolation prize" of placement in a by-clause. An alternative to this divide-the-spoils approach is the winner-take-all solution in which one motivation overrides the others. For English transitive verbs, this solution gives rise to the truncated passive, as in *the pole was hit*. In that solution, the agent is not expressed at all.

### 1.2. Complexity

Complexity arises from the hierarchical recombination of small parts into larger structures. For biological evolution, the parts are the genes. For the brain, the parts are neuronal structures working to generate competing ideas (D. Campbell 1960). For language, the parts are articulatory gestures. In a seminal article entitled *The Architecture of Complexity*, Simon (1962) analyzed higher-level cognitive processes as hierarchically-structured combinations of elementary information processes or modules into which they could be partially decomposed. The basic principles involved can be illustrated by the four levels of structure that emerge during protein folding (N. A. Campbell et al. 1999). In this process, the primary structure of the protein is determined by the sequence of amino acids in the chain of RNA used by the ribosome as the template for protein synthesis. This chain then folds into a secondary structure of coils and folds created by hydrogen bonding across the amino acid chain. These forces can only impact the geometry of the protein once the primary structure is released from the ribosome and begins to contract. Next, a tertiary structure emerges from hydrophobic reactions and disulfide bridges across the folds and coils of the secondary structures. Finally, the quaternary structure derives from the aggregation of polypeptide subunits based on the ternary structures. It is this final structure that allows each protein to serve its unique role, be it oxygen transport for hemoglobin or antigen detection for antibodies. In this partially decomposable emergent system, each level involves a configuration of components from lower levels, but the physical and biochemical constraints operative on each level are unique to that level and only operate once that level has emerged during the process of folding. If a given protein operates successfully, it promotes the adaptation of the whole organism, eventually leading to positive evolutionary selection for the DNA sequence from which it derives. This can be viewed as a type of backwards or downwards causality between levels (Andersen et al. 2000). These principles of partial decomposability, level-specific constraints, and backwards causality apply with even greater force to the study of language, where the interactions between levels and timeframes are so intense. For language studies, the level of analysis achieved in the study of proteomics is clearly not yet possible. However, we can use these principles is to guide our analysis of linguistic levels, cue strength, and the ways in which levels mesh (Labov 1972).

### 1.3. Timeframes

To understand how cues combine in real time, we must examine inputs from processes that are sensitive to inputs across very different timeframes. This integration is particularly important for understanding the connections between psycholinguistic processes and historical change. The usual assumption here is that adaptive changes in the moment lead to long-term typological shifts (Bybee 2010). However, to elaborate these models we will need rich longitudinal corpora that can allow us to study changing patterns over time. In the area of child language acquisition, the CHILDES corpus (MacWhinney 1991) has begun to fill this need. However, the fields of second language acquisition, sociolinguistics, neurolinguistics, or language typology will need much greater amounts of publically available longitudinal data to understand the details of timeframe linkages.

Integration across levels occurs at the moment of speaking as we activate patterns in motor cortex that then lead to articulatory gestures and phonation. Before this final volley of excitation, our brains have integrated competing information from a wide variety of stored lexical, prosodic, constructional, and conceptual patterns. Although these patterns reveal their interactions in the moment, their relative strength and scope has been shaped by hours, days, or even decades of usage. Across these various timescales, patterns have come to adjust their input to the ways in which they can be expressed in the moment. For example, the WXDY construction found in *what is this fly doing in my soup* (Kay and Fillmore 1999) only surfaces rarely. When it occurs, it expresses a unique configuration of shock or pretended shock regarding some untoward condition, and either enough social solidarity to withstand the intended irony or else a power differential that allows for expression of some level of approbation or even accusation. These various sociolinguistic and affective assignments depend on the computation of the status of personal relations as they have developed across days, months, and years. These computations must then be linked to more immediate practical judgments regarding the unexpected nature of the condition (i.e., the fly in the soup). If the relevant preconditions are not fulfilled, we may select a more neutral statement, such as *Oh goodness, there is a fly in my soup.*

In order to understand how the brain links such inputs across diverse timeframes, it will help to take a detour into the simpler world of the honeybee. Menzel (1999) explains how honeybee cognition relies on five memory phases, each involving different cellular processes, different timeframes, and different environmental challenges. The first phase is early short-term memory (eSTM). When foraging within a single patch of flowers of the same type, bees are able to concentrate on a pollen source by resonant activation of a particular neural ensemble (Edelman 1987; Pulvermüller 2003). In the second phase of late short-term memory (lSTM), synthesis of the PKA protein kinase begins to solidify the currently active circuit. The third phase of middle-term memory (MTM) spans a timeframe of hours and involves the formation of covalent modifications in the synapses between neurons. During these first three timeframes, bees have not yet returned to the hive, but are still processing flowers encountered during a single foraging bout. The fourth phase of memory consolidation relies on the formation of early long-term memories (eLTM) through the action of nitrous oxide (NO) and PKC1. This type of consolidation is important, because it allows the bee to return to remembered pollen sources even after a trip back to the hive. The fifth phase of consolidation in late long-term memory (lLTM) operates across a timeframe of over three days, using PKC2 protein synthesis for even more permanent memories. Thus, each of the five phases of memory consolidation is responsive to the nature of the memory that must be retained to allow the bee to continue successful foraging.

When the bee is trying to decide where to fly, her decision is impacted by an array of wheels that mesh in the current moment. Some of the wheels derive from the memories for pollen sources described above. Others derive from activities in the hive, including the dances of other bees. Still others relate to the season, the need to defend the hive, and so on. Bees have an neural module for evaluation that meshes information from all of these sources, much as our language production device serves to evaluate and mesh inputs from all sorts of memories and motives. For both the bee and the human speaker, this meshing of inputs from contrasting timeframes all occurs at the moment of deciding either where to fly or what to say.

This linkage between environmental tasks, timeframes, and neuronal processes is not unique to bees. However, these relations are particularly transparent in the honeybee, because of the way in which the distribution of flowers structures the bee's environment. We find the same five memory mechanisms operating across these timeframes in humans. However, for humans, there are additional mechanisms that support even more complex consolidation over longer timeframes for integrating increasingly complex memories. Many of these additional mechanisms rely on links between the hippocampus and the cortex (McClelland et al. 1995; Wittenberg et al. 2002), including episodic storage in the medial temporal lobes (Daselaar et al. 2004). In addition, the frontal lobes provide a hierarchical system of executive control involving increasingly complex and longer-term structures as one moves from the posterior to anterior frontal areas (Koechlin and Summerfield 2007).

For both bees and humans, behavior is often organized into sequences of repetitive actions. Flying in bees and walking and breathing in humans is based on an iterative closed loop that includes methods for monitoring and stabilizing the iterative process (Feldman 2006). In speech, the basic iterative loop involves the repetitive production of syllables lasting about 150 ms each (Massaro 1975). MacNeilage and Davis (1998) argue that the basic syllable gesture has a CV (consonant-vowel) structure that is homologous to the lip-smacking gesture in other primates. In their frame-content theory, the positioning of the jaw and articulatory closures for the consonant constitutes the "frame" and the positioning of the tongue for the vowel constitutes the "content". The generation of these gestures is controlled by the pars opercularis (Bookheimer 2007) which is the segment of the inferior frontal gyrus nearest to the motor area, which places it next to the motor map for the tongue and lips. In a syllable-timed language like Spanish, this circuit produces a clear periodicity of syllabic gestures. We can think of this process as a wheel revolving with a periodicity of 150 milliseconds. The output of this wheel is then further modified by a second wheel that imposes syllabic stress at the slightly longer timeframe of the metrical foot. The imposition of stress on the syllabic chain can be based either on lexical signals or on conversational emphases.

Short-term processes must mesh with long-term processes. Some of these long-term processes reside not just in neural memories, but also in the memes of social symbolism as they spread through the community (Hruschka et al. 2009). Language is essentially a collection of social memes that becomes internalized within group members. The memes controlling conventions for conversational sequencing, alignment, and focusing also mesh with physical systems for maintaining gaze contact, proxemics, and postural alignment. The analysis of meshing across timeframes can help us understand exactly how motivations compete. In this way, we can better evaluate the claims of the strong functionalist position.

Online meshing takes in motives or pressures from across at least ten major functional domains, each sensitive to inputs from different timeframes. These ten domains include: word production, word comprehension, sentence production, sentence comprehension, language acquisition, diachronic change, interactional maintenance, encounter structure, group membership, and phylogenetic change. Example analyses of how meshing occurs can be found in MacWhinney (2014), Toscano and McMurray (2010), Goodwin (2002), and Poplack and Cacoullos (2014).

## 2. Emergentist approaches

Recent work in linguistics has produced a variety of theoretical frameworks with overlapping goals and assumptions. Among these are functionalism (Givón 1979), Systemic Functional Grammar (Halliday and Matthiessen 2004), Cognitive Grammar (Langacker 1987), Usage-based Linguistics (Bybee and Hopper 2001), Sociolinguistic Variable Rule Analysis (Kay 1978), the Competition Model (MacWhinney 1987), Construction Grammar (Goldberg 2006), Conceptual Metaphor Theory (Lakoff and Johnson 1980), Blending Theory (Fauconnier and Turner 1996), Optimality Theory (Bresnan et al. 2001; Kager 1999), and the Neural Theory of Language (Feldman 2006). In psychology, theories such as Parallel Distributed Processing (Rumelhart and McClelland 1986), self-organizing maps (Kohonen 2001), Bayesian modeling (Kemp et al. 2007), Information Integration Theory (Massaro 1987), and Dynamic Systems Theory (Thelen and Smith 1994) provide quantifiable predictions regarding the outcomes of competition. In addition, formulations from neurolinguistics such as mirror neurons (Arbib 2010), Embodied Cognition (Pecher and Zwaan 2005), and Common Coding (Schütz-Bosbach and Prinz 2007) link up well with many aspects of functionalist linguistics.

Faced with this embarrassment of theoretical riches, students often ask what is the relation between Emergentism and all these other approaches. The answer is that all of these approaches fall under the general category of Emergentism, because all recognize the importance of the principles proliferation, competition, selection, and complexity. However, within this general framework, there is a great diversity of contrasting emphases on specific mechanisms of emergence. We will discuss some of these alternative approaches in the next section. It is also true that, although these approaches utilize the basic concepts of competition and complexity, many of them provide no clear role for the processes that mesh inputs across timeframes. There are some exceptions to this. First, there are sociolinguistic analyses, such as those presented by Poplack and Cacoullos (2014) that have succeeded in tracing changes and continuities in grammar and lexicon over centuries, based on indirect accounts from spoken language data. Second, researchers such as Goodwin (2000), Sfard and McClain (2002), and Lemke (2000) have shown how the use of artifacts (tools, maps, books, color chips, computers) during interaction can provide links to long-term timeframes. Third, researchers in child language (Bates and Goodman 1999) and second language (Verspoor et al. 2011) have developed longitudinal corpora to trace the ways in which competing processes interact across several years. MacWhinney (2005a, 2014) provides further analysis of this issue.

## 3. Mechanisms

Emergentist approaches to language can be characterized most clearly in terms of the emphases they place on alternative mechanisms for language use, learning, and change. In some cases, similar approaches differ only in the detailed computational algorithms they utilize. For example, Parallel Distributed Processing (Rumelhart and McClelland 1986), Self-Organizing Feature Maps (Kohonen 2001), and Dynamics Systems Theory (Thelen and Smith 1994) all represent networks of connections, but differ in the algorithms that operate on these connections. Sometimes there is overlap in terms of both concepts and mechanisms. For example, Construction Grammar (Goldberg 2006) is a direct outgrowth of work in Cognitive Grammar (Langacker 1987), differing largely in terms of the detail with which it analyses competitions between constructions. All emergentist theories recognize the importance of embodied cognition, but they may differ in terms of how they see these effects operating in detail. To understand some of these contrasts, it is helpful to survey some of the most important emergentist mechanisms that have been proposed.

1. Generalization. Many emergentist theories emphasize the basic cognitive mechanism of generalization, often pointing to its basis in neuronal connectivity and spreading activation. Generalization plays a major role as a further support for theories of coercion (MacWhinney 1989), polysemy (Gries this volume), metaphor (Gibbs this volume), prototype application (Taylor this volume), constructions (Perfors et al. 2010), and learning (McDonald and MacWhinney 1991).
2. Error correction. Some learning theories emphasize the importance of corrective feedback, although this feedback can also involve failure to match self-imposed targets, as in the DIVA model of phonological learning (Guenther and Perkell 2003).
3. Self-organization. Mechanisms such as the self-organizing feature map (Kohonen 2001) provide alternatives to mechanisms based on error propagation. An important assumption of these models is that the brain prefers to establish connections between local units, rather than between distant units (Jacobs and Jordan 1992).
4. Structure mapping. Theories of metaphor, metonymy, and analogy in Cognitive Linguistics often assume some method of mapping from the structure of a source domain to a target domain (Gentner and Markman 1997). Mechanisms of this type can also be used to account for convergence between cognitive systems (Goldstone et al. 2004).
5. Embodied representations. The representations and schemata used in Cognitive Linguistics align well with neurolinguistic theories of body image (Knoblich 2008), embodied perspective-taking (MacWhinney 2008c), empathy (Meltzoff and Decety 2003), situated spatial processing (Coventry this volume), and motion processing (Filipović this volume). For further discussion of embodiment, see Bergen (this volume) and Speed et al. (this volume).
6. Item-based patterns. The theory of item-based patterns (MacWhinney 1975, 1982; Tomasello 2000) provides a solid underpinning for Construction Grammar (Goldberg 2006), as well as a systematic answer to the logical problem of language acquisition (MacWhinney 2004).
7. Composition. All syntactic theories must deal with the ways in which words cluster into phrases. Emergentist models of comprehension such as O'Grady (2005) show

how this can be done in an incremental fashion. In this area, the emphasis in UG Minimalism on the Merge process (Chomsky 2007) is compatible with emergentist accounts.

8. Conversational emergence. Linguistic structures adapt to frequent conversational patterns. For example, Du Bois (1987) has argued that ergative marking emerges from the tendency to delete the actor in transitive sentences, because it is already given or known.
9. Perceptual recording. Studies of infant auditory perception have revealed that, even in the first few months, infants apply general-purpose mechanisms to record and learn sequential patterns from both visual and auditory input (Thiessen and Erickson 2014).
10. Imitation. Human children display a strong propensity to imitate gestures (Meltzoff and Decety 2003), actions (Ratner and Bruner 1978), and vocal productions (Whitehurst and Vasta 1975). Imitation in both children and adults is the fundamental mechanism postulated by usage-based linguistics.
11. Plasticity. Children with early left focal lesions are able to recover language function by reorganizing language to the right hemisphere. This plasticity in development is a general mechanism that supports a wide variety of emergent responses to injury or sensory disability (MacWhinney et al. 2000).
12. Physical structures. Phonologists have shown that the shape of the vocal mechanism has a wide-ranging impact on phonological processes (Ohala 1974). Rather than stipulating phonological rules or constraints (Bernhardt and Stemberger 1998), we can view them as emergent responses to these underlying pressures.

This is just a sampling of the many mechanisms and pressures that shape the emergence of language. Understanding how these mechanisms interact to produce language structures is the major task facing emergentist approaches to language.

## 4. Methods

The growth of emergentist approaches to language has depended heavily on the introduction of new scientific methods and the improvement of old methods through technological advances. In particular, we can point to advances in these six methodologies:

1. Corpora. The development of usage-based linguistics has relied heavily on the creation of web-accessible corpora of language interactions, such as those distributed through the CHILDES (Child Language Data Exchange System at http://childes.psy.cmu.edu), TalkBank (http://talkbank.org), and LDC (Linguistic Data Consortium at http://www.ldc.upenn.edu) systems. These databases include transcripts of learners' written productions, as well as spoken productions linked to audio and/or video. As these databases grow, we are developing increasingly powerful analytic and computational linguistic methods, including automatic part of speech tagging (Parisse and Le Normand 2000), dependency parsing (Sagae et al. 2007), lexical diversity analysis (Malvern et al. 2004), and other analytic routines (MacWhinney 2008b).
2. Multimedia Analysis. The construction of an emergentist account of language usage also requires careful attention to gestural and proxemic aspects of conversational

interactions (Goldman et al. 2007). The last few years have seen a rapid proliferation of technology for linking transcripts to video and analysing these transcripts for conversational and linguistic structures (MacWhinney 2007). Longitudinal video corpora are particularly useful for studying the meshing of competing motivations across timeframes.

3. Neural Network Modelling. Neural network modelling has allowed researchers to examine how complex systems can emerge from the processing of input patterns. Increasingly, these systems are linked to benchmark data sets that can be used to compare and test alternative emergentist models (MacWhinney 2010)
4. Neuroimaging. Before the recent period, our understanding of neurolinguistics was dependent primarily on data obtained from brain lesions that produced aphasia. This type of data led researchers to focus on localizing language in specific modules (MacWhinney and Li 2008). However, with the advent of fine-grained localization through fMRI imaging, researchers have been able to formulate emergentist accounts of neural functioning based on the dynamic interactions of functional neural circuits. In addition, it has been possible to use ERP methodology to study competition between languages in second language and bilingual processing (Tolentino and Tokowicz 2011).
5. Neuroscience. Advances in neuroscience have also begun to extend our understanding of cognitive function down to the level of individual cells and local cell assemblies. Although this level of detail is not yet available for imaging methods such as fMRI, ERP, or MEG, we are learning a great deal from the study of single cell recordings in animals (Rizzolatti et al. 1996) and humans undergoing surgery for epilepsy (Bookheimer 2007). This work has emphasized the ways in which the brain encodes a full map of the body, thereby providing support for the theory of embodied cognition (Klatzky et al. 2008).
6. In vivo learning. Until very recently, it has been difficult to study the learning of second languages in realistic contexts. However, we can now use web-based methods (http://talkbank.org/SPA) to study students' learning of second languages on a trial-by-trial basis as they engage in exercises over the web, providing further tests and elaborations of emergentist theories.

## 5. Ten core issues

Over the last three decades, the dialog between Emergentism and UG has revolved around ten core issues.

1. What is Language? UG focuses its attention on the recursive application of rules in the modules of the syntactic component. This emphasis leaves large areas of lexicon, phonology, dialog, meaning, and interpretation outside of the domain of the language faculty. In contrast, Emergentism treats all of the components of human language, including those controlling communication, as parts of an interlocking, unified system.
2. E-Language vs I-Language. UG bases limits linguistic inquiry to the study of the internalized I-Language of the ideal speaker-hearer. Emergentism views language as

arising dynamically from the ways in which speakers reach conceptual consensus (Goldstone et al. 2004; Wittgenstein 1953).

3. The Uniqueness of Recursion. UG views recursion as the crucial defining feature of human language (Hauser et al. 2002). Emergentism views recursion as emerging in contrasting linguistic structures from the combined activities of memory, lexicon, discourse, and role activation (MacWhinney 2009).
4. Rules vs. Cues. Emergentism holds that linguistic structures are not the deterministic rules of UG, but cue-based patterns that arise from usage, generalization, and self-organization (MacWhinney, Malchukov, and Moravcsik in press).
5. Evolution. UG holds that language evolved recently as a way of supporting more elaborate cognition. Emergentism views language as deriving from a gradual adaptation of the human species to the niche of upright posture, communication in large social groups, and support for late infant maturation (MacWhinney 2008a).
6. Genetics. UG accounts seek to link the supposed recent emergence of language to specific genetic changes (Fisher and Scharff 2009) in the last 70,000 years. Emergentism views language as grounded on a wide-ranging set of genetic adaptations across millions of years.
7. Speech is special. Generative theory has often been associated with the idea that, "speech is special." Emergentist approaches to speech and phonological development emphasize the role of physiological mechanisms in controlling articulation (Oller 2000). They also view auditory learning as governed by basic aspects of the auditory system and temporal processing constraints (Holt and Lotto 2010).
8. Critical Periods. Many UG formulations hold that there is an expiration date on the Special Gift underlying language learning and use (Lenneberg 1967). Emergentist accounts attribute the gradual decline in language learning abilities to loss of plasticity through entrenchment of the first language, parasitic transfer of first language abilities, and social isolation (MacWhinney 2012).
9. Modularity. UG emphasizes the encapsulated, modular composition of grammar (Fodor 1983). Emergentist accounts emphasize interactivity between permeable, emergent modules (McClelland et al. 2006).
10. Poverty of the stimulus. UG holds that there is insufficient information in the input to the language learner to properly determine the shape of the native language (Piattelli-Palmarini 1980). As a result, language learning is guided by a rich set of innate hypotheses regarding the shape of Universal Grammar. Emergentist accounts emphasize the richness of the input to the learner and the role of item-based learning strategies in achieving effective learning of complex structures (MacWhinney 2005b).

## 6. Conclusion

This dialog between Emergentism and UG has stimulated three decades of useful empirical and theoretical work. However, Emergentism must now move beyond the confines of this debate. Because Emergentism views language as a meshing of inputs from at least seven structural levels (MacWhinney 2014), these accounts will necessarily be more complex. Fortunately, we can use powerful new methods for qualitative and quantitative analysis of longitudinal multimedia corpora to track the effects of inputs from the many contrasting processes and inputs that shape the totality of human language. Models as diverse as variable rule analysis, dynamic systems theory, and neural networks can be translated into a core language (Farmer 1990) of cue strength and interactive activation. We will need to move ahead on six fronts simultaneously: (1) neurolinguistics and neuroimaging, (2) longitudinal collection of naturalistic and structured corpora, (3) linkage of typology and diachrony to synchronic processes, (4) psycholinguistic experimentation, (5) computational linguistic analysis, and (6) computational modelling. Finally, we must work to interpret the results from each of these six efforts in the context of advances from the other five. We definitely have our work cut out for us.

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