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Review of the Summer Institute in Cognitive Sciences 2010: The Origins of Language

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1.   Overview

During the last two weeks of June, the Faculty of Social Science and Humanities at the Université du Québec à Montréal (UQÀM) organized the *Summer Institute in Cognitive Sciences 2010* (UQÀM 2010, 21–30 June 2010). This year's topic was "the hardest problem in science" (Christiansen & Kirby 2003a) — the origins of language. Language origin refers to the phylogenetic process whereby Homo sapiens made the transition from a pre-linguistic communication system to a communication system with languages of the sort we use today (Wang 1978, Gong 2009). Questions concerning when, where, and how human language (henceforth, simply 'language') originated and evolved belong to the realm of evolutionary linguistics (Ke & Holland 2006, Hauser *et al*. 2007). This field has now become resurgent as a scientific and collaborative beacon for research (Oud-eyer 2006), as shown by many anthologies and reviews; see, among others, Har-nad *et al*. (1976), Wang (1991), Hurford *et al*. (1998), Briscoe (2002), Wray (2002b), Christiansen & Kirby (2003a, 2003b), Cangelosi *et al*. (2006), Smith *et al*. (2008), Bickerton & Szathmáry (2009), Larson *et al*. (2009), and Smith *et al*. (2010).

More than 100 scholars and students from the Americas, Europe, and Asia gathered in Montreal for UQÀM 2010 to study and discuss the outline and recent research of evolutionary linguistics. On each day of the institute, there were five lectures plus one hosted discussion in English. In addition to these lectures and discussions, there were two poster sessions for participants to present their work. The 8 days of lectures collectively introduced a variety of theoretical topics, research methods, and latest findings pertinent to the study of language origins from a range of different fields which included anthropology, archaeology, pale-ontology, neuroscience, genetics, philosophy, psychology, zoology, computer science and linguistics. The lectures covered a wide range of fields, including the history of evolutionary linguistics, animal behaviors, embodiment of language, theories of language origin, computational simulations of language, and pers-pectives about language and its evolution from a number of disciplines.

In section 2, we briefly review the opening presentation of this institute, and then follow this with a description of the plenary lectures in section 3.

Presentations of the poster sessions are not covered by this report, but interested readers may contact the UQÀM 2010 organizers for more information.

2.   Opening Presentation: What Is Language?

On 21 June 2010, the summer institute commenced with an opening address by Ray Jackendoff from Tufts University, who was also awarded an honorary doctorate by UQÀM. In this presentation, Jackendoff reanalyzed the view on the Faculty of Language (FL) articulated by generative linguists (Hauser *et al*. 2002). According to this view, FL consists of FLB (FL in the broad sense) and FLN (FL in the narrow sense): FLB contains sensorimotor and conceptual-intentional capacities, such as auditory channels, working memory, general intelligence, and shared attention, most of which, shared by humans and other species in different levels, are not specific to language; however, FLN involves capacities that are specific to language, and recursion is proposed to be the only component of FLN in Hauser *et al*. (2002). Based on the evidence from visual processing, music recursion, and narrative structure of comics, Jackendoff claimed that recursion was ubiquitous in cognition and, instead of being considered a defining characteristic of language, it should belong to FLB.

Jackendoff further evaluated the Minimalist Program within generative grammar (Chomsky 1993), pointing out that Merge (the operation combining lexical items, according to their intrinsic lexical constraints, into phrases and of combining phrases with each other), as formulated, was not rich enough to handle recursion. Unlike the, what Jackendoff calls, syntacto-centric architecture of language (Chomsky 1993) claiming that the generative capacity of language is localized in the syntactic component where combinatorial properties of sound and meaning are all derived from syntactic derivations, Jackendoff presented his parallel architecture of language (Jackendoff 2002). This structural perspective holds that there are independent combinatorial principles in syntax, semantics, and phonology. Structures from these three components are connected via interface rules and perceptual systems; and instead of being passively manipulated by syntactic derivations, associations between phonological, syntactic, and semantic features are an active part of the interfaces among these components. This view re–positions syntax in language, re–evaluates the relations among linguistic components and general intelligence, and is consistent with the new evidence of human language processing capacities (Jackendoff 2009).

3.   Lectures

3.1.   *History and Outline of Evolutionary Linguistics*

Explorations on language origin date back to the debates of early philosophers and the language deprivation experiments conducted in early dynasties.

Henri Cohen (UQÀM) reviewed some early theories on language, such as Plato's etymological account of words, Fauchet's discussion on individual linguistic knowledge, Alighieri's historical treatment of languages, and Condillac's emphasis on sign languages, most of which were influential to Darwinian and even today's theories on language. He also evaluated some early language depri-

vation experiments conducted in Egypt, India, and Scotland, and showed their contradictory results. The lack of scientific ways of thinking and conducting experiments led to the famous ban on the discussion of language origin from the *Société de Linguistique de Paris* in 1866 (the SLP ban).

Sylvain Auroux (CNRS) examined the philosophical views on language in the 18th century and analyzed two theoretical models proposed during this period. The 'speculative' model focused on individuals and aimed to establish a scenario from minimum hypotheses. Based on this model, Condillac claimed that thoughts were the essential force driving language evolution; language would complete its development if men ceased to generate new needs or ideas. The 'historical' model focused on empirical data and aimed to establish historical relations among languages. Based on this model, Jones believed that many Indo-European languages evolved from a common ancestor. The approach based on the 'historical' model, not rejected by the SLP ban, led to the emergence of historical linguistics, which is one of the most important components of modern linguistics.

Based on these reviews, Cohen listed some outlines of evolutionary linguistics: (i) This field studies FL instead of specific languages, (ii) it focuses on biological capacities and their precursors that enable humans or early hominins to acquire and use languages, and (ii) instead of recovering each step of evolution, it aims to identify selective pressures on language origin and evolution. These outlines provide instructions for evolutionary linguistics research in linguistics and other relevant disciplines.

3.2. *Animal Behaviors and Language*

Comparative studies on other species' culturally varied behaviors could provide us with a sense of the likeliest range of behavioral or cognitive options that early hominins could have taken (Stanford 2006).

Klaus Zuberbühler (University of St. Andrews) provided an update of research on primate vocal communications in natural environments. In order to make comparisons with the physical and behavioral adaptations underlying language, their likely origins in the primate lineage, and their functional roles in communications, this branch of animal studies is usually conducted in the wild using observational sampling techniques or based on non-invasive field playback experiments, covering a wide range of monkeys and ape species (e.g., Cheney & Seyfarth 1990, 2007). At a broader functional level, compared with human communication, many pre–adaptations, such as call combination, social awareness and shared intentionality (Arnold & Zuberbühler 2006 and Pika & Zuberbühler 2007), have been observed in nearly all these species, indicating that during the recent evolutionary history of primates only minor adjustments were necessary to endow humans with FL.

Sue Savage-Rumbaugh & William Fields (Georgia State University) reviewed studies on animal communications based on captive chimpanzees and bonobos, and focused on the signs and lexigrams used by these animals during interactions with human raisers (Savage-Rumbaugh *et al*. 1998). Though limited in vocal communications, these animals can use signs and lexigrams fluently to reflect their minds. Other social skills, such as pointing, joint attention, turn-

taking, and sensitivity to others' minds, were also observed in captive animals during experiments using controlled stimuli.

James R. Hurford (University of Edinburgh) examined the cognitive precursors of linguistic capacities in a variety of animals including birds, dogs, and primates. He reviewed the rich evidence showing that these species can solve the object permanence task, possess the episodic memory for a series of events, represent some abstract properties or relations, do transitive inference, form simple concepts of sameness and difference, have the simple predicate–argument semantic structure, and so on (Hurford 2007). This collection of apparently similar cognitive mechanisms between humans and other species could inspire us to reconsider the singularity of language and relevant learning capacities.

Stephanie A. White (University of California at Los Angeles) focused on songbirds, rather than primates, and used them as behaviorally relevant and physiologically accessible models to determine whether the FoxP2 gene in songbirds functions additionally in their vocal learning and adulthood. She and colleagues found that FoxP2 mRNA in male zebra finches declined rapidly and specifically within the striatal song control region (Area X) when these birds sang, but was stable in non-singing birds. This decline also occurred when males practiced alone, but not when they performed for females (Teramitsu & White 2006). This real-time regulation of FoxP2 during vocalization, dependent on the social context, indicates that FoxP2 functions beyond development and pure motor control (White *et al*. 2006).

3.3. *Embodiment of Language*

This line of research examines questions of how human capacities make language, especially speech, possible and how these capacities affect each other during language processing and communications.

Examining factors involved in the emergence of speech could help to search for answers to language origin. Based on the favored phonetic forms in the babbling and early words of present day infants, Peter F. MacNeilage (University of Texas at Austin) claimed that three forms of CV-like syllables — coronal stop consonants with front vowels (e.g., "dada"), dorsal stop consonants with back vowels (e.g., "gogo"), and bilabial nasal consonants with central or low vowels (e.g., "mama") — constitute the fundamental property of speech (MacNeilage & Davis 2000). Following the 'putting the baby down' scenario (Falk 2004), he suggested that parental terms, possessing present day equivalents to the phonetic forms of the first words, are modern copies of language fossils, and that the second words resulted from the requirement of linguistic distinctiveness applied to the parental forms (MacNeilage 2008).

Lucie Ménard (UQÀM) found that universal tendencies in sound representations observed in languages could be explained in light of individuals' sensorimotor constraints. By listing favored vowels and consonants in some language inventories extracted from the UCLA Phonological Segment Inventory Database, she suggested that these recurrent sound patterns were deeply rooted in physical constraints related to the speaker's vocal tract shape and motor control, and to the listener's perceptual mechanisms. Similar constraints derived from open-close jaw cycle and perceptual saliency also found ways to cause the preferred

syllable structures such as CV and CVC in languages. These universal sound patterns and syllable structures were also attested in babies' babbling and first word inventories (MacNeilage & Davis 2000).

Based on paleoanthropological fossils, a solid understanding of the shape of the vocal tract of human ancestors can shed light on the emergence of speech. In light of head morphology and genetics, Louis-Jean Boë (CNRS) introduced a method of reconstructing vocal tract geometry from skulls with mandible and cervical vertebrae. Arguing against Lieberman's claim that the unlowered larynx with respect to the high position of hyoid bone in newborns and Neanderthals makes it impossible for them to produce the full range of phonetic contrasts, such as /i/, /u/, and /a/ (Lieberman & Crelin 1971, Lieberman 1972), Boë combined phylogenetic reconstruction and ontogenetic data to show that there is no obvious descent of larynx in phylogeny and that it is not necessary to have a low larynx to produce the cardinal vowels /i/, /u/, and /a/ in infants; instead, it is the cognitive capacity for motor control (e.g., feeding gestures as an exaptation for the control of speech production) that should be considered for the emergence of speech.

Nathalie Tzourio-Mazoyer (CNRS) studied multiple factors besides handedness that could affect the hemispheric asymmetry of language areas. She found that the brain volume and asymmetry of left planum temporale (LPT, an auditory area more developed on the left side in the general population; Geschwind & Levitsky 1968) could best explain the variability measured in speech comprehension. She also presented evidence that subjects who had left-handers in their family exhibited a reduction in the surface area of the LPT. This evidence indicates the existence of a genetic influence on hemispheric specialization of language, and supports the hypothesis that perceptive constraints on speech processing can affect the development of hemispheric language organization, which is compatible with the motor and gestural theories of language origin.

David Poeppel (New York University) introduced a method to construct explicit 'linking hypotheses' between brain mechanisms and linguistic computation. After explaining the cortical organization of speech processing, he proposed a dual-stream model in which constituent elementary computations were mediated by an array of cortical areas (Hickok & Poeppel 2007). The MEG studies on cortical rhythms showed that the phase of low frequency responses recorded from human cortex (e.g., theta range) could be a sensitive neuro-physiological index of online speech processing. Other studies combining EEG/fMRI recordings (Giraud *et al.* 2007) further showed that the spontaneous power fluctuations of human brain intrinsic oscillations were paralleled by specific modulations of neural activity in auditory/temporal cortices and correlated with the mouth premotor area. This evidence implies common cortical oscillatory frequency bands for speech production and perception, and provides a supportive brain-based account for the frame/content theory of evolution of speech (MacNeilage 1998).

3.4. Anthropological Perspectives on Language

Anthropologists and archaeologists were among the first group of scholars trying to construe language origin. Paleoanthropological records of extinct hominins

can reveal evidence of presence or absence of bony conformations associated with speech, and archaeological records can provide information of every approximate levels of cognitive and social complexity of extinct hominins.

Based on the tooth fossils of Neanderthals, Jean-Jacques Hublin (Max Planck Institute for Evolutionary Anthropology) examined the life history of Neanderthals. This study can facilitate assessment of growth and development in hominins with greater precision than skeletal analyses, since during tooth formation, biological rhythms manifested in enamel and dentine, creating permanent records of growth rate and duration. Hublin and colleagues found that the period of tooth formation of Neanderthals was shorter than that of Modern humans, implying that a prolonged childhood and slow life history could be unique to Homo sapiens, as other biological adaptations and aspects of social organization (Smith *et al.* 2007).

Based on the archaeological evidence of stone tool-making, Ian Tattersall (American Museum of Natural History) claimed that, because the appearance of modern symbolic cognition (ca. 70,000 years ago) considerably post-dated that of anatomically modern humans (ca. 160–200,000 years ago), the peripheral structures permitting speech must have been acquired in an exaptive context, unrelated to language use, and that besides an internal conduit to thought, language must have been a candidate for the role of cultural releaser (Tattersall 2009).

Based on the analysis of the ornament materials excavated from the Middle Stone Age caves in southern Africa, Christopher Henshilwood (University of Bergen) and Benoît Dubreuil (UQÀM) argued that the creation of such symbolic artifacts relied upon a higher level of theory of mind, which is impossible for non-human primates or young human children due to their simple social categorization abilities. And since such a high level of theory of mind is an important prerequisite for language (Tomasello 2008), they further argued that the appearance of symbolic artifacts implied the origin of some form of language.

Following the assumption that nonlinguistic phenotypes are usually associated with the origin of language, Francesco D'Errico (CNRS) analyzed the knapping techniques shown in stone tool-making of early hominins. These techniques could reveal the ability of hierarchical thinking and syntax of actions, and the recurrent appearance of such techniques in Africa could be the evidence rejecting the hypothesis of the abrupt origin of language in Africa. In addition, the analysis of the symbolic use of marine shells and mineral pigments by Iberian Neanderthals showed that European Neanderthals were no different from coeval Africans (Zilhão *et al.* 2010), which questions the hypotheses of the exclusive origin of language in Africa.

Jean-Marie Hombert (CNRS) focused on populations of early hominins. The number of Homo sapiens was extremely small during the early development of human communication system. The early increase in human population was influenced especially by natural events, whereas the more recent increase in population correlated with the impact of agriculture and the spread of linguistic groups. Besides population size and density, he suggested that the heterogeneous make-up of the population was also a relevant factor in the current development of linguistic diversity.

From the anthropological perspective, Alan Barnard (University of Edin-

burgh) suggested that language development proceeded in several revolutionary phases, including (i) the 'signifying revolution', during which early Homo sapiens started to use words to classify things, (ii) the 'syntactic revolution', during which rudimentary syntax emerged to formulate complex kinship descriptions, and (iii) the 'symbolic revolution', during which fully-developed syntax, music, art, religion, and fully-developed kinship structures all became available. He pointed out that the evolution of story-telling, legends and myths, as culturally important means of expression, played significant roles in creating the linguistic complexities we see today.

3.5. Philosophical and Psychological Perspectives on Language

Denis Bouchard (UQÀM) proposed a philosophical perspective on the origin of structural properties in language. He suggested that language developed as a part of a complex human adaptive suite, all traits of which came from the micro-anatomical brain structures with offline potentials. Such an offline brain system allowed meanings and forms to meet through their representations, thus forming the elementary element of language, uni-signs (meta-representation linking an acoustic image with a concept). Then combi-signs (combinations of uni-signs) and uni-signs collectively triggered the structural properties in phonology and syntax.

Dan Sperber (Institute Jean Nicod) proposed a pragmatic account of language origin. He suggested that language communication is not a 'coding model' in which the communicator encodes meanings into utterances, but an 'inferential model' in which the communicator helps the addressee by giving evidence of her meaning, and the addressee infers the meaning from this evidence and the context. The success of inferential communication is mainly due to the mind reading ability in humans, and does not require identical semantic representations in utterances. Therefore, it is common that the linguistic utterances we use today are full of semantic ambiguities and referential indeterminacies. Being disposed to treating uncoded communicative behavior as a coded signal facilitates the inferential comprehension of the communicator's intention, thus leading to the stabilization of this kind of behavior as a signal. The relatively rapid evolution of language and the relatively high heterogeneity of linguistic knowledge within a community are possible only if the function of language communication is to provide evidence of the speaker's meaning and not to encode it directly (Sperber & Origgi 2009).

Pierre Jacob (Institute Jean Nicod) further argued that communicative intentions were a special sort of social intentions, requiring a high level of meta-representation ability, which challenged the view that the mirror neuron activity alone could enable the addressee to represent the speaker's communicative intention.

Michael Tomasello (Max Planck Institute for Evolutionary Anthropology) studied language origin from a psychological perspective. He claimed that collaborative activities acted as the pre-existing social context for human communication. Within this cooperative context, natural gestures helped to form pragmatic infrastructure, and later, conventional symbols and constructions, as much more powerful means of communication, became possible in larger communities.

To support this cooperation-first hypothesis (Tomasello 2008), he provided evidence that human infants could use natural gestures, especially pointing, to convey their intentions and make use of common ground (shared experience) to read social intentions of the experimenter and to cooperate in realization of shared goals, whereas the pragmatic complexity reflected in referential choices was absent in communications of apes (Tomasello 2009). Based on this evidence, he concluded that linguistic conventions are possible only if the shared intentionality infrastructure is in place.

Stevan Harnad (UQÀM) emphasized the role of human categorization mechanism in language origin. He proposed that language came into existence when purposive miming became conventionalized into arbitrary sequences of shared names used for describing and defining new categories via propositions. Most categorical knowledge in humans is not inborn but learnt via two ways: through direct experience (induction) shared by most species or through word of mouth (instruction) only possessed by humans. He demonstrated this theory in three ways: Artificial-life simulations illustrated the evolutionary advantages of instruction over induction, human electrophysiology experiments revealed the shared features in the two ways of acquiring categories, and graph-theoretic analyses showed that our lexical dictionaries consist of a core set of concrete words learned more early from direct experience and a peripheral set of words learned later by combining core words into subject.

3.6. Social and Genetic Perspectives on Language

Following a social perspective, David Sloan Wilson (Binghamton University) introduced the 'multi-level selection theory' for language, which states that the evolution of socio-cultural behaviors like language must involve multi-level selections within an individual and within or between groups of individuals, and culturally evolved meaning systems could guide adaptions at the individual and group levels, as well as cultural transmission of language.

From a genetic perspective, Karin Stromswold (Rutgers University) reported how genetic findings informed theories of language evolution through family aggregation, adoption, and twin studies. She found that genetic factors affected articulation and syntax more than vocabulary, indicating that syntax and phonology might evolve with similar selective pressures separate from that of lexicon, and that there was genetic overlap between linguistic and non-linguistic skills, indicating that language could have shared an evolutionary history with non-linguistic abilities such as motor or social skills (Stromswold 2009). She suggested that the current genetic research should focus on whether it was a natural selection or exaptation process by which the genetic factors subserving language came into being, and whether there were language-specific genetic factors or whether they all 'piggy-backed' (Tomasello 2008) on other abilities.

Wolfgang Enard (Max Planck Institute for Evolutionary Anthropology) presented a molecular genetic study which introduced two amino acid replacements into the endogenous FoxP2 gene of mice and compared these partially 'humanized' mice with the wild-type ones, and showed that, although the mice with substitutions were generally healthy, they had qualitatively different ultrasonic vocalizations and decreased exploratory behaviors and dopamine con-

centrations in their brains. These results indicated that the humanized FoxP2 allele could affect basal ganglia (Enard *et al.* 2010). Considering that the wild-type FoxP2 protein can be viewed as an ancestral version of the human FOXP2 (to distinct FoxP2 in other species) protein, this study indicated that alterations in cortico-basal ganglia circuits could be crucial for the evolution of speech and language in humans.

Terrence Deacon (University of California at Berkeley) analyzed the role of relaxation of natural selection on language. He hypothesized that function-al redundancy could relax selection on other structures or functions, in which accumulated mutations could produce some variants. These variants tend to dedifferentiate but may also complement the functions of others, thus initiating their synergistic effect. Using finches as an example, he found that domestication of finches could remove the stabilizing effect of sexual selection and degrade constraints on song generation. Following the relaxed sexual selection pressure, other neural influences could cause the song structures to be increasingly subject to social influence. He claimed that such a genetic dedifferentiation effect might contribute to the functional complexity in language. The similar relaxation role could allow cross-talks among cerebral cortical systems in human brains, and the unmasked selection for new functional synergies could cause anatomical re–organization, thus leading to a coevolution of human brains and language (Deacon 1997). Such coevolution proceeded in a context of niche construction (Laland *et al.* 1999 and Day *et al.* 2003): Once a language-like behavior became critical to a hominin's life, it would effectively become an artificial niche to which hominin brains had to adapt.

3.7. *Theories of Language Origin*

Compared with early philosophical theories, modern theories of language origin are internally coherent, drawn from empirical and comparative evidence in humans and other species, and many parts of them can be systematically evaluated based on methods from different disciplines besides linguistics.

Modern theories of language origin are usually based on the concept of *proto-language*. Proto-language refers to the hypothesized early form of language used by our last common ancestor in the hominin family, which does not exhibit the full range of structural properties as modern languages. For example, in light of the 'ontogeny recapitulating phylogeny' analogy from biology and studies on language acquisition, pidgins and creoles, Bickerton proposed the 'lexical proto-language hypothesis' (Bickerton 1990), which states that modern languages with hierarchical structures originated from a lexical proto-language consisting of a few words and without syntactic structures, and that this origin process was achieved via exaptation and a series of niche construction processes. Jackendoff (2002) further extended this theory by listing several developmental stages from one-word utterances, to a proto-language without hierarchy, and finally to a modern language with sophisticated syntax and phonology.

At UQÀM 2010, Maggie Tallerman (Newcastle University) evaluated the lexical protolanguage hypothesis, listing some arguments for it based on examples of languages from non-industrialized communities. In addition, Luigi Rizzi (University of Siena) proposed four successive steps in the origin of

syntactic computations, from simple access to the lexicon, to *primary merge* resulting two-word utterances, to *recursive merge* leading to head-phrase utterances, and finally to *phrasal merge* allowing infinity of phrases with complex specifiers. These steps are consistent with the lexical protolanguage hypothesis. Based on the rapidity of acquisition and early appearance of abstract syntactic knowledge in human young children, he pointed out that there must be an 'instinctive tendency to speak' in humans that calls for an evolutionary explanation.

Apart from oral languages, much recent research focuses on gestures and its roles in language origin. This interest arose partially due to the flexible and context-independent gestures used by chimpanzees in the wild (Pollick & de Waal 2007) and the relative success in teaching signed, instead of spoken, languages to captive chimpanzees and bonobos (Gardner & Gardner 1969 and Savage-Rumbaugh *et al*. 1998).

Based on the evidence from gestures of great apes, development of signed languages, and studies on handedness and cerebral asymmetry, Michael C. Corballis (University of Auckland) proposed the 'gestural proto-language hypothesis' (Corballis 2002), which states that proto-language was in the form of gestures and gradually shifted to speech. The recently-found mirror neuron system in monkeys served as the key component in linking action and speech, and the essential overlap between the mirror neurons in monkeys and the homologous areas for language in humans indicated that language could be incorporated in the human mirror neuron system (Rizzolatti *et al*. 1991, Rizzolatti & Craighero 2004). Corballis proposed several causes for the shift from manual gestures to vocal gestures, such as pedagogy and energy demand, and pointed out that, despite the present dominance of speech, manual gestures could accompany speech in various ways.

Aiming to bridge praxis and communication, Michael A. Arbib (University of Southern California) further examined the neural bases for the gestural origin of language. He modeled the mirror system for execution and observation of actions, and used it as an analogy to the human mirror neuron system for production and perception of words and constructions in language (Arbib 2005).

W. Tecumseh Fitch (University of Vienna) reconsidered the 'musical proto-language hypothesis' proposed by Darwin (Darwin 1871), which states that proto-language was musical, full of phonological and syntactic regularities but lacking rich meanings, and that our ancestors produced musical phrases with holistic meanings before the advent of words and syntax as in modern languages (Fitch 2010). The second part of this theory is in line with the 'holistic proto-language hypothesis' (Wray 2002a, Mithen 2005, Arbib 2008).

In addition to evaluating this theory, Fitch incisively advocated testing this and other theories of language origin empirically. He emphasized the comparative approach, and constructed a comparative database covering many non-human species to identify *homology* and *analogy/convergence* of linguistic mechanisms in humans (Fitch 2010). Homology could help to pinpoint the origin of broadly shared traits in the hominin family, and analogy/convergence could help to locate cases in which similar traits evolved independently in separate lineages such as primates and birds. Both of homology and analogy/convergence

would provide new insights on the evolution of language and linguistic capacities. He also noticed that molecular genetics based on comparative data could help to test models of language evolution and eventually discover the appearance order of different linguistic modules.

According to Tallerman, there is an ongoing discussion on the nature of proto-language (Tallerman 2007, Smith 2008). And as pointed out by Fitch, the comparative evidence and new methods from relevant disciplines besides linguistics could certainly contribute to this discussion.

3.8. Computational Modeling of Language

In evolutionary linguistics, computational modeling can be viewed as the 'operational' hypotheses expressed in computer programs (Parisi & Mirolli 2007), and the results of these programs become the empirical predictions derived from the incorporated hypotheses. It can evaluate existing theories, explore theoretical constructs, exemplify how a theory works, and predict new experimental research (Christiansen & Kirby 2003a), all of which help to transform developmental theories from a descriptive science into an explanatory science (Jäger *et al*. 2009). Together with empirical experiments, computational modeling has become a new means to explore language evolution.

Simon Kirby (University of Edinburgh) argued that language resulted from biological evolution, individual learning and cultural transmission (Brighton *et al*. 2005). He proposed an 'iterated learning framework' (learning by observation of behavior in another that itself was learned in the same way) and simulated it in computational models to examine the roles of cultural trans-mission on language. The results of these models showed that the 'transmission bottleneck' (a learner is given incomplete information) makes cultural transmission become an adaptive system and language has to adapt itself (by showing certain design features such as compositionality) to 'fit' such bottleneck (Brighton *et al*. 2005). Besides simulations, he and colleagues also designed human subject experiments and showed similar results that after several rounds of iterated learning, an initially random language gradually become structured and easier to learn (Kirby *et al*. 2008). All these support a 'design without a designer' view on language evolution.

Morten H. Christiansen (Cornell University) examined the relations between cultural and biological evolutions. Based on the simple recurrent network model (Elman 1991), he examined whether word order in language could derive from sequential learning constraints. The simulation results showed that cultural evolution could overpower biological adaptation, that sequential learning constraints could lead to structural features in language, and that linguistic forms fitting these constraints could become more readily learned and spread among individuals, all of which reflect the 'language is shaped by the brain' view (Christiansen & Chater 2008). Further experiments on human subjects revealed that there are similar neural and genetic bases for sequential learning and language, and that sequential learning provides important constraints on cultural evolution of language.

Based on the recruitment theory that language originates and evolves by recruiting cognitive operations for the purpose of symbolic communication (Steels 2009), Luc Steels (Free University Brussels) presented a series of compu-

tational and robotic experiments on language evolution. Each experiment adopted a particular language game (Loreto & Steels 2007) to specify some challenge, which eventually led to the emergence of certain features in language, such as color lexicon, tense, aspect, or expressions of roles of participants in events. These experiments showed that FL could be formed by the epigenetic recruitment and configuration of distributed networks supporting the language strategies culturally emerging in a population, and that both the recruitment mechanism and the adopted neuro-computational functions were not necessarily unique for language.

Using robotic experiments, Stefano Nolfi (Institute of Cognitive Sciences and Technologies) examined how simple communicative forms originated and changed in a population of initially non-communicating robots, what conditions were the prerequisite for such emergence, and how signals and meanings got grounded in individuals' sensorimotor states. In these experiments, a pair of robots, equipped with motors, signalers for sending light signals, and sensors for detecting others' signals and environmental information, were placed in an environment with marked patches, and gradually evolved, based on their ability to travel, to occupy the same or different patches to each other. A primitive communication system emerged in which the robots used simple forms of light signals to indicate position information. Although such forms were naive compared with language, these studies were useful for exploring the fundamental conditions and strategies for language origin.

3.9. *Linguistic Perspectives*

Unlike other disciplines that examine the ancient remains of language-like behaviors, general cognitive capacities in humans or other species, or processing of artificial languages by automatic agents or human subjects, linguistic studies on language evolution largely follow the 'historical' model and rely firmly on various forms of historical or ontogenetic language data.

Bernard Comrie (Max Planck Institute for Evolutionary Anthropology) illustrated how linguists, using the comparative method based on the typological data from languages in different historical periods, such as Latin, Sanskrit, Ancient Greek, Old High German, or Modern German, and those from the *WALS* database (Haspelmath *et al*. 2008), reconstructed the consonant sys-tem of Proto-Indo-European, regular sound change patterns, and evolving structural complexity in phonetics and morphology. This comparative method not only helps linguists to reconstruct the origins of particular languages, but also sheds light on the universal typological features across languages.

Claire Lefebvre (UQÀM) reanalyzed Bickerton's (1990) approach that uses pidgins and creoles as an analogy to protolanguage and language origin. Based on the analysis of the recent data on pidgins and creoles around the world, Lefebvre pointed out that pidgins are not reduced codes, different from creoles only in lexicon size and fluency. Moreover, according to Lefebvre, pidgins do have syntax, and arise by means of relabeling. In contrast to Bickerton's opinion, she concluded that pidgins and creoles do not provide a window of protolanguage or language origin, since they usually emerged gradually in a multilingual society in need of a lingua franca.

Bernd Heine (University of Cologne) introduced grammaticalization theory as a window on language origins (Heine & Kuteva 2007). This theory makes use of diachronic data to reflect on historical changes in phonology and syntax, following the assumption that grammatical change taking place in contemporary languages is driven by similar forces that exert their influences on languages in history. Heine exemplified how to apply the grammaticalization theory to reconstruct the origins of grammar in language, and showed that this theory allows us to speculate and reconstruct possible forms in early languages outside the scope of historical linguistics.

4. Conclusions

UQÀM 2010 offered a great opportunity for scholars and students from various disciplines to share ideas, methods, and latest findings on language origin and evolution. The lectures at this institute provide several important guidelines for future work on language evolution. First, language can be realized in aspects other than speech, such as signs or writings; linguistic research on these aspects can reveal both the general features of language and specific ones to speech. Second, language is created, acquired, and used by its users; comparative evidence on language processing or general cognitive capacities (e.g., episodic memory, shared intentionality, theory of mind, sequential learning, recursive thinking, etc.), neural and genetic bases for these capacities (e.g., the mirror neuron systems and FoxP2 gene), and archaeological remains of language-like behaviors (e.g., tool-making and symbolic ornaments) can collectively examine the foundations of language in humans. Third, language is inseparable from its socio-cultural environment; social or simulation studies on the emergence and evolution of communication system can reveal the nature of linguistic functions and the roles of cultural transmission in shaping linguistic features. As concluded by Bernard Comrie in the closing presentation of UQÀM 2010, studies on language origin and evolution have to be multi-disciplinary; no single discipline can come close to the answer to this hardest question in science, and knowledge, approaches and findings from many relevant disciplines together can contribute significantly to our understanding on language and its evolution.

What also clearly emerged from the institute is that the field of linguistics as we know it today plays a minor role in such a multi-disciplinary enterprise. There was a shared sense that phylogeny does not recapitulate ontogeny, and that therefore the study of fully developed modern human languages cannot offer a window on the origins of language in early humans. Within modern linguistics, it seems, the only promising domains of enquiry appear to be the following three: Speech sciences, psycholinguistics, and, most likely, grammaticalization as conceived of by Heine. This is a good wake-up call for a field that has progressively cut itself off from other scientific domains due to increased specialization of theory-internal discourses that function as firewalls against not only multi-disciplinary collaboration but also exchange between linguists of different persuasions. It also alerts us to the fact that, after years of assuming that there might be a cognitive dimension to language, it is time to go and look for it where it is actually supposed to reside, rather than speculate on its nature through abstract

representations, be they trees, logical formulas or anything else. Despite Jacken-doff's valiant attempt to save syntax from the demise that Chomsky's recent notion of 'merge' condemns it to, approaches such as Tomasello's have convincingly shown us that there are more interesting lessons to be learnt elsewhere (Ansaldo 2009). The study of language origins paradoxically may have little use for much of linguistics, unless linguists are prepared to move away from the questions that have preoccupied them for the past half century, and turn to questions of real social, historical, and scientific significance in order to seek a biologically plausible, computationally feasible, and behaviorally adequate understanding of language and language evolution.

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