These are exciting times for all those who have refused to listen to the Société Linguistique de Paris. Investigation of the origins and evolution of language is back, and investigators have a whole new range of knowledge and methodologies to bring to the task. Among the most exciting of the new scientific tools – for all of the reasons that Cangelosi and Parisi outline in their introduction – are computer models designed to simulate aspects of some biological, psychological, and sociological processes that may have been involved in the origins and evolution of language. The problem, of course, is that a simulation is a simulation of something, and it is very useful if that something is available for inspection and comparison – which is not exactly the case for things that have occurred in the ancient past. Cangelosi and Parisi bemoan “a very limited, in a sense nonexistent, empirical base”.

But when the focus is on process, as it is for many modelers, the situation is actually a bit different. There are a number of processes currently occurring in the natural world that were very likely involved in the origins and evolution of language. These can be studied empirically, and simulations can be compared to them. For example, many of the people engaged in computer simulations have attempted to benefit from recent research on such things as non-human primate communication; child language acquisition; imitation and cultural learning; and processes of language change, especially those involved in pidginization and creolization.

My research involves the first three of these sets of processes, broadly conceived as processes of primate communication and social learning, including as a special case child language acquisition. I use observational and experimental
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techniques, not modeling, and indeed I often fail to comprehend in detail how many models work. Therefore, the most important contribution I can make to the simulation enterprise – which I think is an extremely important one – is to help it to get its facts straight in those areas in which I have some expertise. I focus on what I consider to be seven important facts.

Non-human Primate Communication

1. Vervet monkey alarm calls are not direct precursors for language

Many scientists outside the field take as the paradigm case of non-human primate communication the alarm calls of vervet monkeys. The basic facts are these (Cheney and Seyfarth, 1990). In their natural habitats in east Africa vervet monkeys use three different types of alarm calls to indicate the presence of three different types of predator: leopards, eagles, and snakes. A loud, barking call is given to leopards and other cat species, a short cough-like call is given to two species of eagle, and a “chutter” call is given to a variety of dangerous snake species. Each call elicits a different escape response on the part of vervets who hear the call: to a leopard alarm they run for the trees; to an eagle alarm they look up in the air and sometimes run into the bushes; and to a snake alarm they look down at the ground, sometimes from a bipedal stance. These responses are just as distinct and frequent when researchers play back previously-recorded alarm calls over a loudspeaker, indicating that the responses of the vervets are not dependent on their actually seeing the predator. On the surface, it seems as if the caller is directing the attention of others to something they do not perceive or something they do not know is present. These alarm calls would thus seem to be referential and therefore good candidates for precursors to human language.

But several additional facts argue against this interpretation. First, no ape species has such specific alarm calls (Cheney and Wrangham, 1987). Since human beings are most closely related to apes, it is not possible that vervet monkey alarm calls could be the direct precursor of human language unless apes at some point used them also. Indeed, the fact is that predator-specific alarm calls are used by a number of non-primate species who must deal with multiple predators requiring different types of escape responses – from ground squirrels to domestic chickens (Marler, Evans and Hauser, 1992) – although no one considers these as direct precursors to human language. Second, vervet monkeys do not seem to use any of their other vocalizations referentially. They use “grunts” in various social situations (and some ape species have similar “close” calls as well; Cheney and Seyfarth, 1990), but these mainly serve to regulate dyadic social interactions such as grooming, play, fighting, and sex, not to draw attention to outside entities. Alarm calls thus are not representative of other monkey calls and so they do not embody a generalized form of reference. Third, primate vocalizations are almost certainly not learned, as monkeys and apes raised outside of their normal social
environments still call in much the same way as those who grow up in normal social environments (although some aspects of call comprehension and use may be learned; Tomasello and Zuberbühler, in press). One would think that language could only have evolved from socially learned and flexibly used communicative signals.

2. Apes use gestures more flexibly than vocalizations – but still not referentially

Our nearest primate relatives, the chimpanzees, actually communicate in more flexible and interesting ways with gestures than with vocalizations. Although they have a number of more or less involuntary postural and facial displays that express their mood (e.g., piloerection indicating an aggressive mood and ‘play-face’ indicating a playful mood), they also use a number of gestures intentionally, that is, in flexible ways tailored for particular communicative circumstances. What marks these gestures as different from involuntary displays and most vocalizations is: (i) they are clearly learned as different individuals use different sets of them; (ii) they are used flexibly both in the sense that a single gesture may be used in different contexts and in the sense that different gestures may be used in the same context; and (iii) they are clearly sensitive to audience as the signaler typically waits expectantly for a response from the recipient after the gesture has been produced (Tomasello, George, Kruger, Farrar and Evans, 1985).

In their natural communication with conspecifics chimpanzees employ basically two types of intentional gesture. First, “attractors” are imperative gestures aimed at getting others to look at the self. For example, when youngsters want to initiate play they often attract the attention of a partner to themselves by slapping the ground in front of, poking at, or throwing things at them (Tomasello, Gust, and Frost, 1989). Because their function is limited to attracting attention, attractors most often attain their specific communicative goal from their combination with involuntary displays; for example, the specific desire to play is communicated by the involuntary ‘play-face’, with the attractor serving only to gain attention to it. The second type of intentional gestures are “incipient actions” that have become ritualized into gestures (see Tinbergen, 1951, on “intention-movements”). These gestures are also imperative in function, but they communicate more directly what specifically is desired. For example, play hitting is an important part of the rough-and-tumble play of chimpanzees, and so many individuals come to use a stylized ‘arm-raise’ to indicate that they are about to hit the other and thus initiate play. Many youngsters also ritualize signals for asking their mother to lower her back so they can climb on, for example, a brief touch on the top of the rear end, ritualized from occasions on which they attempt to push her rear end down mechanically.

Interestingly, in using their gestures chimpanzees demonstrate an understanding that the bodily and perceptual orientation of the recipient is an important precondition for the gesture to achieve its desired goal. Thus, young chimpanzees use their visually based gestures only when the recipient is looking at them, whereas they use more contact-based gestures when the recipient is oriented in another direction (Tomasello, Call, Nagell, Olguin and Carpenter, 1994). Nevertheless, they still do not use their gestures referentially. This is clear because (1) they almost invariably use them in dyadic contexts – either to attract the
attention of others to the self or to request some behavior of another toward the self (e.g., play, grooming, sex) – not triadically, to attract the attention of others to some outside entity; and (2) they use them exclusively for imperative purposes to request actions from others, not for declarative purposes to direct the attention of others to something simply for the sake of sharing interest in it or commenting on it. Thus, perhaps surprisingly, chimpanzees do not point to outside objects or events for others, they do not hold up objects to show them to others, and they do not even hold out objects to offer them to others (Tomasello and Call, 1997).

Following from the initial excitement of the discovery of referentially specific monkey alarm calls, a number of scholars have recently cautioned against using human language as an interpretive framework for nonhuman primate communication (Owings and Morton, 1998; Owren and Rendell, 2001). According to these theorists, non-human primate communicative signals are not used to convey meaning or to convey information or to refer to things or to direct the attention of others, but rather to affect the behavior of others directly. If this interpretation is correct – and it is certainly consistent with the facts outlined above – then the evolutionary foundations of human language lie in the attempts of individuals to influence the behavior of conspecifics not their mental states. Attempting to influence the attention and mental states of others is a uniquely human activity, and so must have arisen only after humans and chimpanzees split from one another some 6 million years ago.

Relevant to this, from their earliest communicative attempts before language, young human children demonstrate this ability by pointing for others declaratively, holding up things to show them to others, offering objects to others, and in general engaging in a number of joint intentional activities by means of which they follow into, direct, and share attention with other people (Tomasello, 1995). This suggests that the social-cognitive prerequisites for language actually concern a much deeper and wider set of joint attentional and social learning activities.

Non-human Primate ‘Culture’ and Imitation

3. Nonhuman primate culture is different from human culture in important ways

Since language involves cultural transmission, it is important to see whether human cultural transmission has any unique qualities. There currently many reports in the popular press that some non-human primates, especially chimpanzees, live in cultures – and indeed they do in the most general sense of that term. But there are differences between human and non-human primate culture, especially with regard to the transmission mechanisms involved.

The best known case of non-human primate culture is the potato washing of Japanese macaques. Although the “spread” of potato washing as a novel behavior in one group of human provisioned Japanese macaques is well known, it turns out that the most likely explanation for that behavior is individual learning, with some
influence of the social environment. It is likely that one individual invented the behavior by walking into the water with the potatoes thrown to her by humans, and her relatives and friends followed her into the water with their potatoes and invented the behavior for themselves (Galef, 1992). Supporting this interpretation is the fact that potato washing is much less unusual a behavior for monkeys than was originally thought. Many monkeys brush sand off food naturally, and indeed potato washing has also been observed in four other troops of human-provisioned Japanese macaques – implying at least four individuals who learned on their own. Also, in captivity individuals of other monkey species learn quite rapidly to wash their food when provided with sandy fruits and bowls of water (Visalberghi and Fragaszy, 1990).

A much better species for investigating possible cultural processes in is chimpanzees, who have many population-specific behaviors (and in the absence of human provisioning). The best known example is chimpanzee tool use. For example, chimpanzees in the Gombe National Park (as well as several other groups elsewhere) fish for termites by probing termite mounds with small, thin sticks. In other parts of Africa chimpanzees simply destroy termite mounds with large sticks and attempt to scoop up the insects by the handful. Field researchers such as Boesch (1993) and McGrew (1992) have claimed that specific tool use practices such as these are “culturally transmitted” among the individuals of the various communities. The problem is that it is possible that chimpanzees in some localities destroy termite mounds with large sticks because the mounds are soft from much rain, whereas in other localities there is less rain, so the mounds are harder, and thus the chimpanzees there cannot use this strategy. In such a case there would be group differences of behavior – superficially resembling human cultural differences – but with no type of social learning involved at all. In such cases the “culture” is simply a result of individual learning driven by the different local ecologies of the different populations (and so it is sometimes called ‘environmental shaping’).

The human case is very different. Human beings have species-unique modes of cultural transmission involving imitation and teaching and this leads to some different types of cultural traditions and artifacts. Most importantly, the cultural traditions and artifacts of human beings accumulate modifications over time – so-called cumulative cultural evolution. Basically none of the most complex human artifacts or social practices – including tool industries, symbolic communication, and social institutions – were invented once and for all at a single moment by any one individual or group of individuals. Rather, what happened was that some individual or group of individuals first invented a primitive version of the artifact or practice, and then some later user or users made a modification, an “improvement”, that others then adopted perhaps without change for many generations, at which point some other individual or group of individuals made another modification, which was then learned and used by others, and so on over historical time in what has sometimes been dubbed “the ratchet effect” (Tomasello, Kruger and Ratner, 1993).

The process of cumulative cultural evolution thus requires not only creative invention but also, and just as importantly, faithful social transmission that can work as a ratchet to prevent slippage backward – so that the newly invented artifact
or practice may preserve its new and improved form at least somewhat faithfully until a further modification or improvement comes along. Perhaps surprisingly, for many animal species it is not the creative component, but rather the stabilizing ratchet component, that is the difficult feat. Many non-human primate individuals regularly produce intelligent behavioral innovations and novelties, but then their groupmates do not engage in the kinds of social learning that would enable, over time, the cultural ratchet to do its work (Kummer and Goodall, 1985).

4. Chimpanzees learn socially not by imitation but by emulation and ritualization

Although environmental shaping is likely a part of the explanations for group differences of behavior for all species, experimental studies have demonstrated that more than this is going on in chimpanzee culture. Tomasello (1996) reviewed all of the experimental evidence on chimpanzee imitative learning of tool use and concluded that chimpanzees are very good at learning about the dynamic affordances of objects that they discover through watching others manipulate them, but they are not skillful at learning from others a new behavioral strategy per se (but see Whiten and Cunstance, 1996). For example, if a mother rolls over a log and eats the insects underneath, her child will very likely follow suit. This is simply because the child learned from the mother’s act that there are insects under the log – a fact she did not know and very likely would not have discovered on her own. But she did not learn how to roll over a log or to eat insects; these are things she already knew how to do or could learn how to do on her own. (Thus, the youngster would have learned the same thing if the wind, rather than its mother, had caused the log to roll over and expose the ants). This is what has been called emulation learning because it is learning that focuses on the environmental events involved – the changes of state in the environment that the other produced – not on a conspecific’s behavior or behavioral strategy (see also Nagell, Olguin and Tomasello, 1993).

Chimpanzees are thus very intelligent and creative in using tools and understanding changes in the environment brought about by the tool use of others, but they do not seem to understand the instrumental behavior of conspecifics in the same way as do humans. For humans the goal or intention of the demonstrator is a central part of what they perceive, and indeed the goal is understood as something separate from the various behavioral means that may be used to accomplish the goal. Observers’ ability to separate goal and means serves to highlight for them the demonstrator’s method or strategy of tool use as an independent entity – the behavior she is using in an attempt to accomplish the goal, given the possibility of other means of accomplishing it. In the absence of this ability to understand goal and behavioral means as separable in the actions of others, chimpanzee observers focus on the changes of state (including changes of spatial position) of the objects involved during the demonstration, with the motions of the demonstrator being, in effect, just other motions. The intentional states of the demonstrator, and thus her behavioral methods as distinct behavioral entities, are simply not a part of their experience.

In terms of communicative behavior, as alluded to above, virtually no chimpanzee vocalizations are learned, and the gestures that are learned are not
learned by imitation but rather by a process of ritualization in which individuals mutually shape one another’s behavior over repeated social interactions (Tomasello, 1996). For example, it is likely that the ‘arm-raise’ gesture to initiate play originates as follows:

1. an initiating chimpanzee youngster begins rough-and-tumble play with another by play hitting;
2. after repeated instances of this the recipient begins to anticipate the impending hit on the basis of the first part of the sequence (the raising of the arm) and so begins the rough-and-tumble play at that early point in the sequence;
3. the initiator notices the recipient’s anticipation and connects the raising of its own arm with the beginning of the play; and
4. on some future occasion the initiator comes to use its ‘arm-raise’ in order to elicit play – often in a stylized manner with no attempt to actually hit, waiting for a response from the recipient.

The ‘arm-raise’, which was originally a preparation for instrumental action, has become an intentional communicative signal used to elicit play from others. Evidence for ritualization as the major, if not exclusive, process of chimpanzee gesture learning was presented by Tomasello, Call, Warner, Carpenter, Frost, and Nagell (1997) who found that: (i) some individuals used gestures that no other group member used (thus precluding imitation as a means of acquisition), (ii) individual variability in types of gestures used by individuals of the same group was very high, whereas many gestures were shared between isolated groups; and (iii) in an experiment, no chimpanzees in a captive group copied a novel gesture used (frequently) by one of their groupmates.

Non-human primate communication and tool use thus provide us with two very different sources of evidence about social learning. In the case of gestural signals, it is very likely that chimpanzees acquire their communicative gestures through a process of ontogenetic ritualization. In the case of tool use, it is very likely that they acquire the tool use skills they are exposed to by a process of emulation learning. Both ontogenetic ritualization and emulation learning require skills of cognition and social learning, each in its own way, but neither requires skills of imitative learning in which the learner comprehends both the demonstrator’s goal and the strategy she is using to pursue that goal – and then in some way aligns this goal and strategy with her own. Indeed, emulation learning and ontogenetic ritualization are precisely the kinds of social learning one would expect of organisms that are very intelligent and quick to learn, but that do not understand others as intentional agents with whom they can align themselves.

It may be objected that there are a number of convincing observations of chimpanzee imitative learning in the literature, and indeed there are a few. However, basically all of the clear cases in the exhaustive review of Whiten and Ham (1992) concern chimpanzees that have had extensive amounts of human contact. In many cases this has taken the form of intentional instruction involving human encouragement of behavior and attention, and even direct reinforcement for imitation for many months; for example, Hayes and Hayes (1952) provided their chimpanzee Vicki with 7 months of systematic training, and Whiten and Custance
(1996) provided their two chimpanzees with 4 months of systematic training. This raises the possibility that imitative learning skills may be influenced, or even enabled, by certain kinds of social interaction during early ontogeny, a point suggested especially strongly by the study of Tomasello, Savage-Rumbaugh, and Kruger (1993) in which it was found that the imitative learning abilities of so-called enculturated chimpanzees (raised like human children) were much better than those of mother-reared captive chimpanzees, who imitated almost never. This fact may have some implications for the co-evolution of skills of teaching and imitative learning.

5. Human children integrate an understanding of intentions into social learning

In contrast — and as a foundation for the ratchet effect — human children reproduce rather faithfully the intentional actions of others, which of course requires an understanding of their intentions. For example, Meltzoff (1988) had 14-month-old children observe an adult bend at the waist and touch his head to a panel, thus turning on a light. Most infants then performed more or less this same behavior — even though it was an unusual and awkward behavior and even though it would have been easier and more natural for them simply to push the panel with their hand. One interpretation of this behavior is that infants understood: (a) that the adult had the goal of illuminating the light; (b) that he chose one means for doing so, from among other possible means; and (c) that if they had the same goal they could choose the same means. Imitative learning of this type thus relies fundamentally on infants’ ability to distinguish in the actions of others the underlying goal and the different means that might be chosen to achieve it. Otherwise, the infants might have engaged in emulation learning in which they simply turn on the light with their hands (which they did not), or else they would have just mimicked the action, like a parrot, without any regard for its goal-directed nature.

Two other recent studies have tested more directly what infants understand about others’ intentional actions in the context of imitative learning. In the first, Meltzoff (1995) presented 18-month-old infants with two types of demonstrations (along with some control conditions). Infants in one group saw the adult perform actions on objects, much as in previous studies. Infants in the other group, however, saw the adult try but fail to achieve the end results of the target actions; for example, the adult tried to pull two parts of an object apart but never succeeded in separating them. Infants in this group thus never saw the target actions actually performed. Meltzoff found that infants in both of these groups reproduced the target actions equally well, that is, they appeared to understand what the adult intended to do and performed that action instead of mimicking the adult’s actual surface behavior. (And they were much better in both of these conditions than in the control conditions in which the adult just manipulated the objects randomly and the like.)

In the second study, Carpenter, Akhtar, and Tomasello (1998) investigated infants’ imitation of accidental versus intentional actions. In this study, 14- to 18-month-old infants watched an adult perform some two-action sequences on objects
that made interesting results occur. One action of the modeled sequences was marked vocally as intentional (“There!”) and one action was marked vocally as accidental (“Woops!”) – with order systematically manipulated across sequences. Infants were then given a chance to make the result occur themselves. Overall, infants imitated almost twice as many of the adult’s intentional actions as her accidental ones regardless of the order in which they saw them, indicating that they differentiated between the two types of actions and that they were able to reproduce, again, what the adult meant to do and not only her surface behavior.

Imitative learning thus represents infants’ initial entry into the cultural world around them in the sense that they can now begin to learn from adults, or, more accurately, through adults, in cognitively significant ways. This learning is not just about the affordances of objects that are revealed when others manipulate them, or just about the surface behavior in the sense of precise motor movements. Instead, from around their first birthdays, human infants begin to tune into and attempt to reproduce both the adult’s intentional acts, including her acts of intentional communication.

Child Language Acquisition

6. Symbols emerge in human ontogeny from more basic skills of joint attention

Pre-linguistic human infants are able to discriminate sounds and associate particular experiences with them. But they do not comprehend and produce linguistic symbols until about their first birthdays. An interesting question is thus: Why not? One hypothesis is that they do not acquire language so early because they do not yet understand the communicative intentions of others. From about their first birthdays, however, infants begin to understand that when other persons are making funny noises at me they are trying to manipulate my attention with respect to some external entity. This understanding is one manifestation of a momentous shift in the way human infants understand other persons – which occurs at around 9 to 12 months of age, as indicated by the near simultaneous emergence of a wide array of joint attentional skills involving outside objects. These include such things as following into the gaze direction and pointing gestures of others, imitating the actions of others on objects, and manipulating the attention of others by pointing or holding up objects to ‘show’ them to others declaratively (Tomasello, 1995).

The first language emerges on the heels of these non-linguistic triadic behaviors (involving you, me, and it) and is highly correlated with them – in the sense that children with earlier emerging skills of non-linguistic joint attention begin to acquire linguistic skills at an earlier age as well (Carpenter, Nagell and Tomasello, 1998). Similarly, children with autism have problems with joint attention and language in a correlated fashion, that is, those who have the poorest non-linguistic joint attentional skills are those who have the poorest language skills (Sigman and Capps, 1997). When children begin to understand the actions of others as
intentional in general, they also begin to understand the communicative actions of others as intentional in the sense that they are aimed at directing attention. This understanding is the sine qua non of true language acquisition conceived as learning conventional symbols for manipulating the attentional and mental states of others.

7. Children's early language is not based on abstract categories

In terms of grammar, recent research suggests that most of young children's early language is not based on any abstract linguistic categories or schemas, and so description of child language in terms of abstract grammars created for adults is fundamentally misguided (Tomasello, 2000a). For example, in a detailed diary study Tomasello (1992) found that most of his English-speaking daughter's early multi-word speech revolved around specific verbs and other predicative terms. That is to say, at any given developmental period each verb was used in its own unique set of utterance level schemas, and across developmental time each verb began to be used in new constructions on its own developmental timetable irrespective of what other verbs were doing during that same time period. There was thus no evidence that once the child mastered the use of, for example, a passive construction with one verb that she could then automatically use that same construction with other semantically appropriate verbs. Tomasello (1992) hypothesized that children's early grammars could be characterized as an inventory of 'verb-island constructions', which then defined the first syntactic categories as lexically based things such as 'hitter', 'thing hit, and 'thing hit with' (as opposed to subject/agent, object/patient, and instrument; see also Tomasello and Brooks, 1999).

Experiments using novel verbs have also found that young children's early language is almost totally concrete – with the exception that they control from early on some very local and item-based structures with abstract but highly constrained 'slots'. For example, Tomasello and Brooks (1998) exposed 2 to 3-year-old children to a novel verb used to refer to a highly transitive and novel action in which an agent was doing something to a patient. In the key condition the novel verb was used in an intransitive sentence frame such as The sock is lamming (to refer to a situation in which, for example, a bear was doing something that caused a sock to “tam” – similar to the verb roll or spin). Then, with novel characters performing the target action, the adult asked children the question: What is the doggie doing? (when the dog was causing some new character to tam). Agent questions of this type encourage a transitive reply such as He's tamming the car – which would be creative since the child has heard this verb only in an intransitive sentence frame. The outcome was that very few children produced a transitive utterance with the novel verb, and in another study they were quite poor at two tests of comprehension as well (Akhter and Tomasello, 1997). In general, it is not until they are 4 to 5 years old that young children are skillful at using novel verbs creatively in novel utterances and constructions in ways that indicate the use of abstract linguistic categories and schemas (see Tomasello, 2000b, for a review).

How do children create more abstract linguistic categories and constructions? Currently the leading hypothesis is that they invoke a relational mapping across different verb island constructions (Gentner and Markman, 1997). For example, in
English the several verb island constructions that children have with the verbs give, tell, show, send, and so forth, all share a ‘transfer’ meaning and they all appear in a structure: NP+V+NP+NP (the ditransitive construction). The specific hypothesis is thus that children make constructional analogies based on similarities of both form and function: two utterances or constructions are analogous if a “good” structure mapping is found both on the level of linguistic form and on the level of communicative function. Precisely how this might be done is not known at this time, but there are some proposals that a key element in the process might be some kind of “critical mass” of exemplars, to give children sufficient raw material from which to construct their abstractions (Marchman and Bates, 1994).

Overall, then, we may say that young children begin by imitatively learning specific pieces of language in order to express their communicative intentions, for example, in one-word utterances (holophrases) and other fixed expressions. As they attempt to comprehend and reproduce the utterances produced by mature speakers – along with the internal constituents of those utterances – they come to discern certain patterns of language use, and these patterns lead them to construct a number of different kinds of (at first very local and then more general) linguistic categories and schemas.

**Conclusion**

Following Parisi and Cangelosi (this volume), I believe that a comprehensive account of language origins and evolution requires attention to three distinct time frames. First, in human evolution what I believe we are looking for is the emergence of the human ability to use symbols (Deacon, 1997). However, my own view is that if we are looking for the major cognitive adaptation underlying language, we must look much more broadly at the human ability to understand others as intentional agents like the self – which underlies not just language but a whole suite of cultural skills (Tomasello, 1999).

Second, of crucial importance in determining the shape of modern languages is grammaticalization and other processes of historical language change. Although I have not dealt with them here (I am not an expert on these matters), these processes have both psychological and sociological dimensions – involving everything from pragmatic inferences to analogical extensions to the spread of novelties due to social status – and they provide the major alternative account (i.e., alternative to Chomskyan nativism) for why modern languages look the way they do (Croft, 2000). A number of modern linguists (e.g., Heine, 1997; Bybee *et al.*, 1994) have argued and presented evidence that the linguistic constructions of individual languages have been built up over generations by groups of people communicating with one another within the general constraints of human cognition, communication, and vocal-auditory processing.

Third, in ontogeny human children hear only concrete utterances but they end up with some abstract linguistic categories and constructions. It is conceivable that they do this with biological machinery specifically dedicated to language and its acquisition, but a variety of lines of recent research are beginning to establish the viability of an alternative view. In this alternative view (e.g., Slobin, 1997; Bates,
1999; Tomasello, 2000b), young children themselves create linguistic abstractions by using general cognitive and social-cognitive skills to find patterns in the way adults are using language when communicating with them. These pattern-finding skills emerge early in human ontogeny and can be applied to a variety of different types of experiences (Saffran et al., 1996; 1999).

Computer simulations of linguistic processes – evolutionary, historical, and ontogenetic – represent an exciting new approach to the question of language origins and evolution. But it is my belief that they can only make real progress with at least a little bit of back-propagation from facts about the way these processes operate in the real world. Ideally, new insights gained from these informed simulations then will lead to novel empirical investigations, which will then lead to better simulations, and so on in one more instance of an important cultural ratchet.

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