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This paper attempts to synthesize how biological-nativist theories emerged as a response to logical and empirical flaws in behaviorist learning theories, and how in turn, recent research findings in Developmental Cognitive Neuroscience and Connectionist models of language acquisition are questioning the present innatist framework. As a result of this questioning, a reconceptualization of the term innateness have been proposed by a group of scientists on the grounds that the issue of "the grammar gene" has kept investigators looking on the wrong places for answers to language acquisition. On the other hand, looking at language acquisition issues from a Developmental Cognitive Neuroscience perspective supported by Connectionist data have provided researchers with a fresh outlook. It is now theorized that: (1) language acquisition is a product of the biologically endowed architectural structures of neural networks that are able to store environmental input; (2) linguistic input is stored in long term memory depending on statistical frequencies; and (3) language production is the result, not of genes, but of the problem of transferring multidimensional representations of thought into a linear (monodimensional) string of words. (Contains 12 references.) (Author/RS)

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This paper attempts to synthesize how biological-nativist theories emerged as a response to logical and empirical flaws in behaviorist learning theories, and how in turn, recent research findings in Developmental Cognitive Neuroscience and Connectionist models of language acquisition are questioning the present innatist framework. As a result of this questioning, a reconceptualization of the term innateness have been proposed by a group of scientists on the grounds that the issue of "the grammar gene" has kept investigators looking on the wrong places for answers to language acquisition. On the other hand, looking at language acquisition issues from a Developmental Cognitive Neuroscience perspective supported by Connectionist data have provided researchers with a fresh outlook. It is now theorized that: (1) Language acquisition is a product of the biologically endowed architectural structures of neural networks that are able to store environmental input (2) Linguistic input is stored in long term memory depending on statistical frequencies; and (3) Language production is the result, not of genes, but of the problem of transferring multidimensional representations of thought into a linear (monodimensional), string of words.

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A CONNECTIONIST APPROACH TO LANGUAGE ACQUISITION

Luis O. Lizardi

Language acquisition ontogeny has been a much debatable issue since the last half of this century. Theories and methodologies have come and gone not after empirical studies whose validity were questionable and/or illogical arguments have been replaced by more valid studies and arguments. Tabula rasa[1] advocates were displaced by those who favored a twist for nature over nurture arguments. In turn, these nativists were influenced by cognitivists views. Now, Connectionist approaches are being used as tools by those interested in language acquisition in order to corroborate neuroscientific discoveries on developmental issues that are beginning to disclose how rasa is our tabula (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1966, p. 99). Thus, Connectionist approaches and developmental neuroscience's findings are newly welcome contributors to the language acquisition debate arena.

Biological-nativist theories of language acquisition emerged as a response to behaviorist learning theories. According to Reynolds and Flagg (1983), these theories had both logical and empirical flaws (p. 345). For example, behaviorists claimed that children acquired language through imitation, contiguity, and reinforcement. Yet, those claims were discredited because (1) although adults never say "sitted", "foots" , or "goed", children do make such generalizations anyhow; Hence, children do not imitate (p. 348), (2) adults seldom produce double negatives, yet children do, and (3) children are resistant to use structures that are beyond their current developmental stage.[2] Likewise, reinforcement claims are rebated with the famous argument from "poverty of input"[3], which by the way, Pinker (1994), pinpoints as the main Chomskian justification for claiming that language is innate.

Advocates of the Neo-Darwinian and Neo-Mendelian approach rely on several major issues to support the innatist framework: for instance, (1) Lennenberg's studies on brain lateralization and critical periods for language acquisition, Broca's aphasia cases, and Lorenz' findings on bird "imprinting"; (2) heredity issues such as the "poverty of input" mentioned earlier, deaf children's sign language emergence (Pinker, 1994, p. 36), pidginization issues, and Creole development; and (3) Chomsky's Language Acquisition Device (LAD).[4] In other words, advocates of these issues, believe that the best explanation for these phenomena is a gene specialized in grammar. Moreover, these issues conform a theoretical framework in linguistics known as Universal Grammar (UG), (Chomsky, in Flynn & O'Neil 1988). According to nativists, UG is the basic innate deductive power underlying all languages of the human species. Yet, Pinker (1994), acknowledges that there is no way of verifying its existence (p.322).

According to Reynolds and Flagg (1983), cognitive psychologists knew that the validity of nativists' arguments presupposed a validity of those biological approaches presented by Lennenberg. In fact, these authors hypothesized that if cognitivists were able to raise sufficient doubts over Lennenberg's positions, they could undermine the myth of the LAD, while leaving unresolved the case for critical periods, and the fact that language is a human endowed behavior. Indeed, recent findings in neural development and connectionist models of language acquisition and learning have torn down not only those innatist issues which dissident cognitive psychologists were conspiring over, but also critical period issues, and even the way in which innate constraints are interpreted.

Consequently, a reconceptualization of the term "innateness" has been proposed by Elman et al. (1996), namely, because scientific discoveries on brain studies have called for a need to assign a different role to genes that the one previously thought. For one thing, genes are not blueprints, and it is generally acknowledged that if there was a single gene mapping each specification, there would not be enough space available in the cells to allocate them all. In fact, Elman and his colleagues argue that genes do not have the need to encode everything, first, because genes do not behave in a descriptive way (p.16), and, second, because they produce enzymes not only by themselves, but by moving around, by recombining with other genes at different stages of development, by fostering mutations to adapt to new situations, and by binding their products with other genes which regulate the original enzymatic effect or the enzymatic product of the gene acted upon (p. 2). This is why Pinker (1994), acknowledges the innexistance of the grammar gene. Hence, Elman et at. (1996), call for a need to rethink what is meant by innateness and invite linguists to reconsider this issue from a different perspective.

But, how can we define innateness? Elman et al. (1996), propose that what is innate are a series of changes that occur as a result of interactions within the organism. These changes occur at three levels: among genes, among molecules, and within neuronal environments. Moreover, modifications also occur during ontogeny without external input from outside the organism (p. 22). Still, Pinker (1994), a strong advocate of nativism, argues that it is precisely those genes which are involved in those processes and which act upon language acquisition what they have been referring as innate grammar genes (p. 322).

Yet, Elman et al. (1996), justify their claim by argumenting that, by maintaining the issue of a grammar gene, investigators are kept looking for answers in the wrong places. For example, in a case of Specific Language Impairment (SLI), Tallal, Stark, and Mellits (cited in Elman et al., 1996), gathered a notable amount of data that suggest that children with SLI are affected by a deficiency in “rapid temporal sequences of auditory and (perhaps) visual stimuli” processing (p. 377). In other words, morphosyntax was not what was impaired. Hence, maintaining a pervasive obstination in the grammar gene issue could be misleading and detrimental (p. 390). In fact, the Elman group warn nativists about the grave consequences that are implied in the use of terms such as “instincts”, especially on the interpretations that certain sociopolitical institutions could wrongfully assign to them.

Still, there are other issues, such as the role of interaction over developmental processes, that are helping to define the new role of innateness. For instance, Elman et al. (1996), stress that development is an ongoing interactive process that occurs at multiple levels in the brain: at neural synapses (p. 25), at neural networks, and at a global brain level (p. 29). Moreover, these authors present several empirical studies that show that developmental changes come as a product of the “interaction of maturational factors under both genetic control and environment” (p. 1). Henceforth, the problem is not one of nature over nurture, or nurture over nature, but one of nature *and* nurture.

For instance, the brain’s neural networks structures determine what kind of information from external input can be processed, what kind of representations can be stored as neural connections, and which kind of problems can be solved by the organism (Elman et al., p. 30). Accordingly, Elman and his colleagues stress that it is this kind of nativism that renders knowledge as innate, and Pinker (1999), acknowledges that “learning is impossible without innately organized circuitry to do the learning: (p.210). In sum, lower levels of circuitry are not innate, whereas macrocircuitry may well be. Still, neuroscientists would have not been able to confirm these assumptions without the help of another newcomer: computer simulated networks.

Connectionist models are the tools which are currently helping scientists understand the enigmatic interactions between the brain and its environment during the process of development (Elman et al., p. 147). For example, this approach has been crucial in the reevaluation and reinterpretation of important issues in both cognition and language acquisition such as the Critical Period Hypothesis, and overregularization of English past-tense verbs, among others.

By way of example, Marchman (cited in Elman et al., 1996), conducted studies with neural networks that involved simulated aspects of grammatical development. Then, these networks were subject to random elimination of 2% to 44% of all connections, resulting in a permanent unproductiveness for further language learning. Finally, the network changed its original structure up to a point where it could no longer start again to relearn the task as usually computer networks do. As Seidenberg (1992), suggests, it is a matter of using it or losing it.

This experiment guided Elman et al. (1996), to conclude that mastery of a skill seems to be the result of sculpting of the neural tissue which attends that cognitive ability (p. 294). Incidentally, from these findings, scientists are concluding that noise might be beneficial because it can keep the brain from sculpting too early, which might prevent it from further learning. Hence, connectionist models are bringing light into the Critical Period issue. Moreover, these scientists suggest that the term Critical Period should be replaced by a more subtle term: Sensitive Period. Accordingly, the term Critical Period refers to a non-specific point in the development process in which organisms are sensitive to experience, and furthermore, these periods do not exhibit drastic termination points (p. 283).

Likewise, connectionist models have helped to solve the puzzle of overregularization of English past-tense verbs. Later, with further acquisition of more vocabulary, children tend to overrregularize already learned irregular verbs until, finally, they acquire adult commandship of the language. Mac Whinney and Leinbach (1990), refer to this phenomena as the U-shaped learning problem (p. 91). Indeed, computer networks experiments have exhibited that same behavior. In their case, overregularization occurs when they learn the rule for "ed" suffixes from substantial statistical probabilities (Seidenberg, 1997).

Connectionist approaches also provide illustrations in word recognition and pronunciations (Seidenberg & Mc Clelland, cited in Seidenberg 1992). For example, Hare and Elman (cited in Elman et al., 1996), conducted a computer simulated study of a model of historical language change: specifically, the great vowel shift. In the study, they showed how the weak "ed" verb class became dominant. Similarly, Rumelhart and Mc Clelland (cited in Mac Whinney & Leinbach, 1990), had previously conducted a much debated research on English past-tense verbs whose findings were highly criticized for the flaws encountered in the implementation of such study. Yet, according to Mac Whinney and Leinbach, those flaws were corrected in a further study and helped improve the model's performance.

In their quest for answers on how language is acquired and used, connectionists have come with a possible explanation of how language is produced. Elman et al., (1996) suggest that:

> human languages emerged within a rich problem space that has little in common with the many other things we do. Put in the simplest possible form, languages represent solutions to the problem of mapping inherently nonlinear patterns of thought onto a linear sequence of signals, under a severe set of processing constraints from human perception, motor coordination and production, and memory. (p. 38).

In other words, grammar is not a product of genes, but a solution to the problem of transferring multidimensional representations of thought into a linear (monodimensional), string of words.

However, the search for a theory of second language acquisition (SLA), is still unanswered. Klein (1990), acknowledges that UG has nothing to offer to SLA research, and proposes that connectionism should be the ideal search framework (p. 219). Moreover, Klein also suggests that differences in the acquisition of first (L^1), and second language (L^2), are a consequence of the different knowledge states in which these kind of learners face input (p. 229). Still, Klein proposes that since learners already know how to implement certain grammatical mechanisms in their native tongue, their only problem is to learn the way in which the target language proceeds with those features

On the other hand, granted that language learning is based on statistical frequencies and distributions of environmental input emergent from cognitive development (Munakata, Mc Clelland, & Johnson, cited in Seidenberg, 1997), then, under this stand, the children's task is to learn how to use language (p. 1601). However, adults engaged in learning a second language face this task with a sculpted brain and may need to spend some time growing synapses and constructing alternative architectures of neural networks for the new mental representations which may need to be stored in areas different from those already automated (sculpted), for L^1 computation. Eventually, connectionist approaches to SLA should address those assumptions drawn from present findings while scientists humbly acknowledge to be in search for better ideas (Elman et al., p. 392).

In conclusion, connectionist approaches to language acquisition are accumulating impressive amounts of data on how language is acquired and used, and how this knowledge is represented in the brain. So far, these findings, along with those from developmental neuroscience, have been largely ignored by both linguists and related professionals in the field. Still, SLA issues need to be addressed under this new limelight along with many other issues that naturally arrive when in the course of heuristics a little question is answered. Connectionism is a sound candidate in which to build future cognitive theories of language acquisition with a solid empirical framework based on the interactions of nature *and* nurture.

Footnotes

[1] A term used by John Locke to describe the blank state of the mind before it is exposed to experience.

[2] An example of this is the classical account of the child that kept saying "Nobody don't like me", even though his mother modeled for him "Nobody likes me" until he produced the utterance "Oh, nobody don't likes me" recorded by Mc Neill (cited in Reynolds & Flagg, 1983; p. 350).

[3] The fact that children learn to use grammars to construct complex and novel language structures without formal instruction is known as "Poverty of Input", or Stimulus. It is also known as "Plato's problem" (Hale, 1988; p. 26).

[4] The LAD as a mental organ was postulated by Chomsky (Clahsen, 1988, p. 48). Its job was to extract regularities form syntax. Later, the LAD was reconceptualized as the Universal Grammar (UG), hypothesis (Steinberg, 1993; p. 138).

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