Ecological Theory of Language Acquisition

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Abstract

This poster outlines an Ecological Theory of Language Acquisition (ETLA). The theory views the early phases of the language acquisition process as an emergent consequence of the interaction between the infant and its linguistic environment. The newborn infant is considered to be linguistically and phonetically naïve but endowed with the ability to register a wide range of multi-sensory inputs along with the ability to detect similarity between the multi-sensory stimuli it is exposed to. The initial steps of the language acquisition process are explained as unintended and inevitable consequences of the infant's multi-sensory interaction with the adult.

The theoretical model deriving from ETLA is tested using the experimental data presented in the two additional contributions from our research team (Gustavsson et al, "Integration of audio-visual information in 8-months-old infants"; Lacerda, Marklund et al. "On the linguistic implications of context-bound adult-infant interactions"). The generality of the ETLA's concept is likely to be of significance for a wide range of scientific areas, like robotics, where a central issue concerns addressing general problems of how organisms or systems might develop the ability to tap on the structure of the information embedded in their operating environments.

1. Introduction

Competent speakers of a language can explore the language's combinatorial power to build up and define novel elements that can be recombined hierarchically to generate entities, to which a potentially endless recursive process can be applied to create new meanings. Indeed, even for finite recursions, the exponential growth associated with the combinatorial principle rapidly leads to such astronomically large numbers of possible sequences that the likelihood of random re-occurrence of a particular sequence becomes vanishingly small. But whereas this combinatorial power is good news for communication purposes, it clearly raises the issue of how a naïve language learner might be able to make sense of this immensely vast linguistic universe. Indeed, the famous argument on the "poverty of the stimulus" points out that the amount of information available from natural sentences is far too limited to allow the naïve language learner deriving the linguistic principles used in the ambient language, unless guided by an innate "language acquisition device" (LAD).

However, in the ecological language acquisition setting the argument of the poverty of stimulus is much less relevant than it appears to be for adult-to-adult speech because the linguistic structure and the information content of the speech input typically directed to young infants is, in fact, rather stereotypical and repetitive (Lacerda, Marklund et al, 2004). The repetitive character of infant-directed speech and the ecological setting in which it occurs offer the grounds for the Ecological Theory of Language Acquisition (ETLA) that is presented in this communication. To be sure, the characteristics of the speech input directed to infants are likely to vary appreciably as a function of the infant's age, but such changes reflect the adult's continuous adaptation to the perceived linguistic development of the infant and fit well in the theoretical model as they complete the picture of the unfolding language acquisition process in its ecological settings.

2. Theory outline

The basic claim of the Ecological Theory of Language Acquisition is that early language acquisition is an emergent consequence of the multi-sensorial embodiment of the information available in ecological adult-infant interaction settings. According to ETLA, the basic linguistic referential function emerges from correlations between two (at least) of the sensory dimensions available in the speech interaction scene (Lacerda, 2003; Lacerda, Gustavsson, & Svärd, 2003). In spite of its simplicity and generality, it is argued that such a correlation mechanism is capable of initially capturing the relevant associations between the sounds of words and some of the sensory characteristics of their referents, given of the special characteristics of the speech input available to the infant and the ecological context in which infant-directed speech occurs. But in order to be able to pick up the referential link the infant must attend to the speech signal and indeed it is known that even newborns display a strong preference towards listening to speech, in particular the mother's voice. Whereas this might be seen as a sign of

innate propensity for speech, the Ecological Theory of Language Acquisition attempts to frame the newborn's preference for the spoken language as the result of a general recognition process that happens to link the infant's pre- and post-natal auditory experiences.

Indeed the newborn's preference for speech can be explained as a consequence of perinatal continuity that does not involve specialized speech-oriented mechanisms. Because the fetus' auditory system is functional by about 150 days after gestation, the newborn's preference for the speech signal may result from the infant's recognition of familiar prosodic and rhythmic patterns from its pre-natal exposure to the speech produced by the pregnant woman. Thus, rather than being a specific interest for speech, as such, the newborn's preference towards speech is seen as a consequence of a general recognition process that would apply to a very broad range of acoustic stimuli to which the infant might have been exposed to before birth. Undoubtedly, under typical circumstances, the speech signal is likely to induce particularly salient representations in the pre-natal infant as a consequence of the pregnant woman's normal spoken interaction, but the crucial point here is that such a salience is not particularly related to the speech signal per se, but rather to its availability as a frequent acoustic signal during the last months of gravidity. Furthermore, because the speech signal available to the fetus is dominated by low frequencies due to the low-pass (LP) filter characteristics of the transmission over the amniotic liquid in which the fetus is immersed, it may be predicted that the newborn will tend to focus on the low-frequency aspects of the speech signal, mainly associated with prosodic and temporal aspects. (Nazzi, Bertoncini, & Mehler, 1998; Ramus, Hauser, Miller, Morris, & Mehler, 2000)

After birth, the infant's recognition of the prosodic patterns of speech fits nicely with the typically enhanced F0 modulations occurring in Infant-Directed Speech, as adults tend to reinforce the phonetic aspects of the speech signal that seem to be preferred by the infant. The newborn's interest for the prosodic characteristics of the speech signal is likely to be an important initial component but, within the framework of the ETLA, it cannot account by itself for the infant's subsequent language acquisition process. Thus, in the pursue of the mechanisms underlying the early language acquisition process, the characteristics of the speech input available to the young infant in its ecological context have to be considered and integrated with the infant's perception and production capabilities.

Although the prosodic characteristics of infant-directed speech (IDS) are most likely engage the young infant's attention (Fernald, 1989), the young infant is obviously also exposed to other types of speech that the infant can hear – like adult-directed speech, (ADS), adult speech directed to children (the infant's older siblings, for example), child to infant, child to adult, etc., in the infant's neighborhood. In fact, an extensive study of the language input available to a Dutch infant between six and nine months of age (van de Weijer, 1999) indicated that IDS, produced by an adult occurred on average for about 14% of the speaking time that the infant was exposed to. Yet, during the period of IDS, the speech was produced with the infant at close range, which is likely to result in high salience for this type of speech. Considering that IDS is typically repetitive and refers to objects and situations in the infant's immediate neighborhood (Lacerda, Marklund et al, 2004, this conference), the salience of the correlated auditory and visual information is likely to be high, providing an optimal ground for the emergence of the linguistic referential function.

3. Modeling early language acquisition

The principles of the Ecological Theory of Language Acquisition are being implemented in a mathematical model of early language acquisition that will be demonstrated in this communication. The model is based on multi-sensory unsupervised hierarchical pattern recognition and general memory processes. It operates on the particular type of input available to the infant in its ecological context. The model results will be tested against experimental data from language comprehension tests carried out with 8-month old infants (Gustavsson et al, 2004, this conference).

The theory of language acquisition proposed in this communication has potential wide implications that go beyond the issue of language acquisition proper. Because it addresses the fundamentals of an emergent learning process, the theory may have significance for general problems concerning the discovery of hidden structure embedded broad classes of multi-dimensional input signals.

Acknowledgements

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