

- Dale, Rick and Michael Spivey. "Unraveling the Dyad: Using Recurrence Analysis to Explore Patterns of Syntactic Coordination Between Children and Caregivers in Conversation." *Language Learning*, v.56 (2006).
- Hsu, Anne and Nick Chater. "The Logical Problem of Language Acquisition: A Probabilistic Perspective." *Cognitive Science*, v.34/6 (2010).
- MacWhinney, B. *The CHILDES Project: Tools for Analyzing Talk*. 3rd ed. Mahwah, NJ: Lawrence Erlbaum, 2000. <http://childes.talkbank.org> (Accessed July 2013).
- Roy, Deb, et al. "The Human Speechome Project." *Proceedings of the Twenty-Eighth Annual Meeting of the Cognitive Science Society* (2006).
- Waterfall, Heidi, Ben Sandbank, Luca Onnis, and Shimon Edelman. "An Empirical Generative Framework for Computational Modeling of Language Acquisition." *Journal of Child Language*, v.37 (2010).

Critical Period in Language Development

This entry describes the tenets of critical period as a concept and how it relates to language learning. This topic is important for researchers who study children with delays in language acquisition and perceptual differences, for example, deafness.

Intimately linked with the complex interaction between nature and nurture, the term *critical period* stems from processes identified in developmental psychology and developmental biology. A critical period can be characterized as a maturational time frame during which an organism has heightened sensitivity to external stimuli that are necessary for the full unfolding of a particular skill. During this time period, if the organism is not exposed to the appropriate stimuli, then the dependent skill may be suboptimal or, in extreme cases, even unattainable. Critical periods have been observed in all species studied, from fruit flies to humans. The chaffinch, for example, must be exposed to an adult's song of its own species before sexual maturation in order to learn its intricate and native song, according to W. Thorpe. Equally, basic sensory processing in humans has been shown to be dependent on learning over certain time windows. The development of binocular vision requires that a child receives visual input to both eyes between 3 and 8 months of age, state R. Aslin and M. Banks. Deprivation of vision up to at

least 3 years of age can result in developmental difficulties in that domain. In contrast, in other, higher-level areas of cognition, there may be no such fixed window of opportunity, for example, word learning. In this case, we would expect to see equal skill development over any age period throughout the life span.

W. Penfield and E. Lenneberg are associated with the proposal of a critical period for first language acquisition. These researchers suggested that the maturational time period when language stimulation must occur for optimal language acquisition was in early childhood, and this constituted an example of biologically constrained learning. If exposure to language was delayed until after 5 years and up to puberty, then development would not benefit from the default mechanism but would be driven by a different set of cognitive processes and ultimately be less successful. This proposal, known as the Critical Period Hypothesis, has been contentious in language acquisition research ever since, with debates concerning the exact definitions of ages and the specificity of what ultimate attainment is. Lenneberg used three main sources of evidence to support the notion of a critical period for language acquisition: (1) feral children and victims of severe neglect who were reared with minimal exposure to language and who subsequently were unable to fully acquire the formal properties of language, specifically the phonology and syntax; (2) children born profoundly deaf who had delayed exposure to a spoken language up to puberty and then presented incomplete language acquisition; and (3) studies of children with aphasia or severe brain damage who had significantly better recovery of language than aphasic adults.

Despite the fact that Lenneberg proposed his hypothesis several decades ago, the extent to which critical periods can be observed in the domain of human language acquisition remains open to empirical investigation. The aim of this entry is to present the evidence currently available and to highlight key areas for further study. Ultimately, the current data suggest that, in some subdomains of language acquisition, but not all, a period of time is evident over which the cognitive system is more responsive to linguistic stimuli. The term *critical period*, however, is too stringent as a descriptor; rather the notion of a set of sensitive or optimal periods may be more appropriate. The distinction is that a sensitive or optimal period describes a window of developmental time over which an individual is optimally responsive to certain environmental inputs, resulting in a temporarily increased

predisposition to learning from those inputs rather than an abrupt change in plasticity.

There are three sources of evidence pertaining to variability in the responsiveness of the language system to external stimuli: the effects of early deprivation, particularly how short-lived deprivation must be for function to develop typically; the efficacy of learning new linguistic skills at different ages; and recovery from damage incurred at different times in the life span. Each of these sources of evidence relates to slightly different aspects of plasticity in the cognitive system, but drawn together, they permit some insight regarding changes in human sensitivity to linguistic stimuli over developmental time.

Early Deprivation: Extreme Deprivation

There have been a series of case studies on so-called feral children who failed to acquire language typically after prolonged periods of extreme deprivation and neglect. The case of Genie, studied by S. Curtiss, who suffered severe neglect until the age of 13, has been particularly well documented. Language outcomes for Genie, especially in phonology and syntax, as for other children exposed to similar conditions, were ultimately poor, suggesting that exposure to language must occur before a given point in development for typical acquisition to occur. However, drawing conclusions from these isolated cases is ill advised given the multiple confounding factors inevitably involved. These children were not only raised in language-poor environments but were also nutritionally deprived and socially isolated and may have had additional preexisting learning difficulties. Given that failure to develop language could be attributable to any one of these factors, evidence regarding a critical period for language is scant.

Neglect

A much larger evidence base was made available through the international adoption of Romanian orphans in the early 1990s. A large research study, led by Sir Michael Rutter in the United Kingdom (UK), was conducted on evaluating the cognitive development of children adopted under the age of 42 months. With respect to language development, C. Croft and colleagues found that children who had been adopted before 6 months of age showed no difference in comparison to control children born and adopted within the UK who had not experienced deprivation. However, around 40 percent of the

children who experienced 6 to 42 months of deprivation showed clinically significant language delays, and language scores for this group remained below the norm when followed up at age 11 years.

Recent studies of internationally adopted children who did not encounter any social or physical neglect but experienced early language exposure in one language before moving to another country in infancy or early childhood, thus losing all exposure to the infancy language, offer an interesting comparison. This group of children show some subtle differences when compared with their nonadopted peers; the specific domains affected are thought to be those around the use of phonological working memory, describe K. Gauthier and F. Genesee. Such work helps to separate out which aspects of delayed language might be attributable to socioemotional versus more purely linguistic factors and suggests that the development of phonology (speech sounds) is particularly sensitive to very early linguistic input.

Congenital Deafness

Much stronger cases of late language development effects in the face of good social and emotional nurture are the signing abilities of deaf children of hearing parents. This group of children (and in the past more so) experienced profound difficulties acquiring spoken language naturally despite good nurturing experiences from their parents. At the same time, this population readily acquired signed languages when they were offered this modality at varying ages during childhood. This natural experiment allowed researchers to examine the ultimate attainment of sign language development in the context of different ages of acquisition in adult signers. These signers often had more than 30 years' experience of using American Sign Language (ASL) and, in contrast to studies of second language acquisition, had developed their language skills without the interference of a first language. R. Mayberry and E. Eichen compared adults with different ages of acquisition of ASL on a sentence-shadowing experiment. They reported that adults who had begun to acquire their first language at later ages found the task to be more difficult and produced a greater number of phonological errors, suggesting slower processing of language. In comparison, native signers produced semantic errors, but fewer phonological ones. In the same study, Mayberry and colleagues reported that a group of deaf adults who learned ASL as a second language after having acquired spoken English as

a first language during infancy performed like native signers on this task. The argument was exposure to any language during the critical period for phonological development enabled later language learning to build on these representations. In a second experiment, P. Boudreault and Mayberry compared native and non-native signers' abilities to perform grammaticality judgement tasks, again finding that age of acquisition affected adults' abilities, a fact they attributed to a possible critical period for language development. Similar results were reported for British deaf adults by K. Cormier and colleagues. Importantly, the participants in these studies had good nonverbal cognitive abilities including memory.

Connected to Lenneberg's proposal that reduction in brain plasticity after the onset of puberty links to ultimate language attainments, work by Mayberry and colleagues has showed that a delayed acquisition of a first language results in changes in the functional organization of the adult brain and also changes in gray and white matter concentrations in the occipital cortex. Mayberry argues that late language exposure leads to a different wiring of the brain for language processing, but this might not be related to cortical lateralization.

For typically hearing individuals, speech perception is not solely an auditory process. Rather, visual cues from the talking face confer considerable advantage, especially under conditions of auditory noise, according to K. Grant and S. Greenberg and many others. Recent research with children born deaf has hinted at a sensitive period for the development of the integration of auditory and visual speech signals. Audiovisual speech perception was tested in children born with profound deafness who had been fitted with cochlear implants (prosthetic hearing devices) in early childhood. The results from E. Schorr, N. Fox, V. van Wassenhove, and E. Knudsen showed that the ability to integrate heard and seen speech stimuli declines with age, given implantation over the age of 2½ years. This suggests that a sensitive period may exist in low-level processing, namely the integration of stimuli from different modalities, which may impact the efficacy of language development at more abstract levels.

Second Language Acquisition

The key questions are these: Is it possible to learn a new language later in life to the same standard as a native language? And, why might learning later in life be more difficult and slower than learning a language

in infancy? To answer the first question, a number of studies have assessed the linguistic competence of individuals who have moved to a new country after puberty. In their 2001 paper, D. Birdsong and M. Molis assessed native Spanish speakers who moved to the United States on their ability to spot grammatical errors in spoken sentences. The authors found that accuracy on this task correlated with age of arrival over 17 years but not for those who moved to the United States under the age of 17. This suggests that, although learning may be easier before puberty, it gradually declines after. These results can be compared with other studies, for example, J. Johnson and E. Newport, that showed declines before 17 years and no correlation with age of acquisition thereafter. These data suggest there is no obvious terminal point, leaving little support for the idea that puberty is a cutoff, contrary to the Critical Period Hypothesis as originally stated. The extent to which this is true depends on how closely related the first and second language are in terms of grammatical structure and speech sounds. Interestingly though, there may be a stronger effect for learning the sounds of a new language.

At the brain level, research by H. Neville and D. Bavelier has shown that variation in age of exposure to second languages results in different neural representations. Acquisition of first languages in native speakers results in strongly left-lateralized processing; however, second language acquisition results in more variability in the neural activity for processing that language as well as less lateralization. If this is due to age or to maturation of cortical lateralization is not clear. In summary, ultimate attainment varies by a number of factors—what area of language is assessed, age of acquisition, similarity between first and second languages, and likely numerous individual differences such as motivation and time spent in the language environment. In general, there is evidence for reduction in ability over time on average but not for a critical period as such overall.

Recovery From Damage

The last set of evidence for a critical period comes from neuropsychology, where it is known that adults who are beyond puberty are more likely to suffer permanent language impairment from brain damage than are children who experience similar brain lesions. The origin of this difference is again linked to cortical reorganization, which is still in progress in children, so language acquisition can benefit more from

compensation during this period. As an example, some children who have experienced hemispherectomy, as documented by F. Vargha-Khadem and colleagues, can develop speech and language with native-like abilities despite having no left hemisphere. However, there is also evidence for language reorganization after stroke in adults, and this area is open to much debate.

Conclusion

There are several sensitive periods for native language acquisition, with the command of the phonological level being most critically tied to the earliest exposure but also exposure in early childhood being tied to native use of syntactic abilities. Evidence from variable ages of exposure to signed languages points to these early effects being long lasting and having an impact on the brain mechanisms dedicated to language. Thus, the more formal properties of language show the most effects of age of acquisition, however, not in an all or nothing fashion. Late learners can acquire the basic word order and syntactic operations of the language successively, but exposure out of childhood does mean that more marked or complex grammatical structures are not acquired in a native-like way. This attenuation rather than cutoff is not seen as a problem for several domains of learning outside of languages but is a particularly contentious issue in language acquisition. The deaf research also suggests that early exposure to any language can transfer to subsequent attainments, pointing to the importance of early and high-quality exposure to a native sign language as being crucial for subsequent acquisition of a spoken language.

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See Also: Adoption Studies of Second First-Language Acquisition; Age of Acquisition Effects; Bilingualism: Interactions Between Languages; Early Second Language Acquisition; Focal Lesions and Language Development; Language Development in Children With Cochlear Implants; Language Development in Deaf Children.

Further Readings

Anderson, V., M. Spencer-Smith, and A. Wood. "Do Children Really Recover Better? Neurobehavioural Plasticity After Early Brain Insult." *Brain*, v.134/8 (2011).
Birdsong, D. "Age and Second Language Acquisition and Processing: A Selective Overview." *Language Learning*, v.56/s1 (2006).

Cormier, K., A. Schembri, D. Vinson, and E. Orfanidou. "First Language Acquisition Differs From Second Language Acquisition in Prelingually Deaf Signers: Evidence From Grammatical Processing of British Sign Language." *Cognition*, v.124 (2012).
Newport, E. L. "Critical Periods in Language Development." In L. Nadel, ed. *Encyclopaedia of Cognitive Science*. London: Macmillan, 2002.
Rutter, M., et al. "Effects of Profound Early Institutional Deprivation: An Overview of Findings From a UK Longitudinal Study of Romanian Adoptees." *European Journal of Developmental Psychology*, v.43 (2007).

Cross-Cultural Factors in Communicative Development

Language learning takes place in a cultural context through interaction with adults and more advanced language users. Across cultural-linguistic groups, children learn the language of the community in very similar ways. Children first learn the sounds of the language and put sounds into words. In early development and throughout the life span, children (and adults) comprehend many more words than they express. Across languages that have very different structures and word order, children consistently appear to learn more nouns in early development compared to verbs. The noun-verb distribution, however, is moderated by the structure of the language children are learning.

For example, children learning verb-friendly languages such as Japanese or Mandarin may learn more verbs in early acquisition than children learning noun-friendly languages such as English. Once children learn approximately 50 words, they start to combine words into phrases. As children learn the particulars of the language they are learning, they add words to their vocabularies to express their experiences. The classes of words they learn (e.g., nouns, verbs, possessives, and routines) are influenced by their everyday experiences and by the structure of the language they are learning. This means, for example, that children in different environments may learn different sets of nouns and verbs and other word classes, and these reflect their experiences.

In addition to learning the vocabulary and grammar of their language, children must also learn