Chapter 2
Timing Matters: Dynamic Interactions Create Sensitive Periods for Word Learning

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ABSTRACT
What is the nature of sensitive periods in lexical development? In this chapter, the authors propose a novel dynamic view of sensitive periods. They suggest that they are periods of heightened interaction and adaptation between organism and environment that are the emergent result of the changing developmental landscape. In support of this perspective, the authors first provide an extended model of word learning to show that language moves through a predictable sequence of sensitive periods, each serving as a building block for the prior. Next, they show how changes in the timing of sensitive periods can affect early word learning in the case of two populations—preterm infants and children with cochlear implants. Finally, the authors provide a theoretical overview of how typically developing infants move from basic perception to full-blown language across several domains of language, and how changes in the timing of the input and response can lead to changes in developmental outcomes.

INTRODUCTION
The notion of sensitive periods during development is far from novel. We remember Konrad Lorenz (1937) principally for his discovery of a critical time, just after birth, during which goslings imprint upon their mother by following the first object that moves in their visual field. Hubel and Wiesel (1970) reached similar fame for their work with kittens demonstrating the importance of early visual input in the formation of ocular dominance columns in the neocortex. They found that if input from one eye is restricted, then the parts of the brain devoted to input from that eye are similarly underdeveloped, and at a certain point, those parts of the brain will always be stunted even if input to the restricted eye is restored.

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These examples capture the most important point about sensitive periods: that the timing of input matters for development. If input is restricted or changed at a crucial moment, outcomes can be dramatically different from typical development. If newly hatched goslings did not see mother goose, for example, but instead saw Konrad Lorenz, those goslings followed Lorenz. If kittens did not get visual feedback while walking, they never learned to use sight to walk.

This chapter asks the question: What happens in language development when the timing is atypical? Is restricted or altered input just as devastating to language development as it is for other developmental outcomes? In short, how does altered timing alter development?

Fortunately, we shall see that there is good news: Humans prove far more plastic when it comes to learning a language than kittens or geese did in the above examples of sensitive periods. Language appears especially resilient to altered inputs or timing. In a way, language HAS to be resilient, since individual languages themselves are all very variable (even encompassing different modalities, such as sign language). Children must be able to discover their native language despite sometimes rather dramatic differences in the types and timing of input they get.

All is not sunshine and roses, however. Sadly, case studies such as the wild boy of Aveyron and the tragic story of Genie, who were severely deprived of language input, provide support for the idea that language must be learned within a certain time window. In both cases, even after years of therapy neither was capable of functional language. Combining such anecdotal evidence with the struggles of late second language learners leads to the general consensus that at least some aspects of language, particularly phonology and grammar, must be learned before the onset of puberty or else they may never be learned with the same fidelity (Curtis, 1977; Lenneberg, 1967; Lenneberg & Lenneberg, 1975).

How might one explain sensitive periods from a modern developmental perspective? Our own theoretical account (Gogate & Hollich, 2010) and that of many others (e.g., Spencer, et al., 2009; Smith, 2005) suggests that certain aspects of language emerge in a particular order, and that language development moves through a predictable sequence of sensitive periods as a function of the combined interaction of organism and environment. In this view, certain parts of language are simply easier to learn (e.g. words that relate to concrete, visible objects in the environment) than others, and learning some of those easier aspects of language may be crucially important to subsequent development (e.g., learning the connection between social intent and referent; also see Hollich, Hirsh-Pasek, & Golinkoff, 2000). By way of example, we have suggested that infants’ discovery of certain perceptual regularities (amodal invariants) provides fundamental gateways to subsequent language learning. If it is the case that order matters, then a change in the timing of input or in the readiness of the organism to perceive specific inputs should have predictable and potentially significant consequences on how language develops, even preventing further development under some circumstances. At minimum, examining the effect of altered timing and the resulting change in sensitivities will provide additional evidence for or against current theories of language development (ours included) and help elucidate the complex nature of sensitive periods themselves.

In this chapter, we examine how changes in the timing can affect early word learning. In doing so, we further develop our interactive model of lexical comprehension development, proposed in Gogate and Hollich (2010; see preliminary model in Gogate, Walker-Andrews, & Bahrick, 2001) called the Multisensory Underpinnings of Lexical Comprehension Hypothesis (MULCH). In this model, we described the qualitative shifts that occur from 2 to 24 months as infants move from learning auditory-visual relations to learning...