

Introduction

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Approaches to Bootstrapping. Volume 1 : Phonological, lexical, syntactic and neurophysiological aspects of early language acquisition

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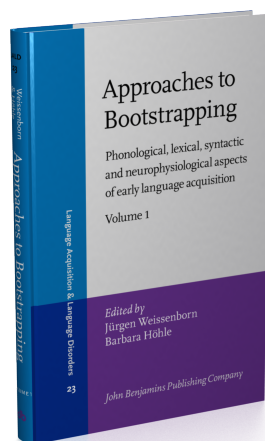
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Introduction

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There is growing consensus that by the age of three children have acquired the basic phonological, morpho-syntactic, and semantic regularities of the target language irrespective of the language or languages to be learned, and the language modality in which learning takes place, i.e., spoken or signed language. Evidence is also accumulating that the schedule for the major milestones of language development in the productive as well as in the receptive mode is largely identical from language to language (for a detailed overview see Jusczyk 1997).

How is this early learning or bootstrapping into the native language possible? The notion of bootstrapping implies that the child (on the basis of already existing knowledge and information processing capacities) can make use of specific types of information in the linguistic and non-linguistic input in order to determine the language particular regularities which constitute the grammar and the lexicon of her native language. Depending on the type of information which the child makes use of, we can distinguish prosodic, lexico-semantic, conceptual, morpho-syntactic, and pragmatic bootstrapping. The central assumption behind the bootstrapping approach is that there is a systematic relationship between properties of the input at one level of representation, which the child already has access to, and another level of representation. An example is the intensively studied parallelism between prosodic and syntactic structure, or between lexico-semantic and syntactic structure (e.g., Gleitman 1990; Pinker 1994). In other words, the child makes use of the regularities that characterize the interface, i.e., the interaction between different linguistic and non-linguistic domains of representation. A problem with this strategy is, as has repeatedly been pointed out, that this parallelism between levels of representation is only partial (e.g., Selkirk 1984; Jackendoff 1997). The child must thus use other means to solve the problems that result from this type of discrepancy. It could be

that the child makes use of different types of information in order to overcome these difficulties (Hirsh-Pasek & Golinkoff 1996; Mattys, Jusczyk, Luce & Morgan 1999; Morgan, Shi & Allopenna 1996).

Other questions related to the process of bootstrapping are whether and how the bootstrapping strategies and their interrelation may change during development. Such a change is to be expected given the constantly increasing knowledge of the child in the linguistic and non-linguistic domain. For example, the growing lexicon of the child, especially in the domain of the closed class, functional vocabulary which in languages like English, French or German constitute about 50% of the lexical tokens of any given text, should considerably facilitate and enhance the lexical (e.g., word segmentation and categorization) and syntactic (e.g., determination of syntactic boundaries) bootstrapping capacities of the child because of the distributional properties of these items. That is, from a very early stage, the child should be able to apply — albeit only to a certain extent — an adult-like top-down parsing strategy (e.g., Höhle & Weissenborn 2000). We may thus have to reckon with a constantly changing hierarchy of bootstrapping strategies. The extent to which these changes may result in the attrition of bootstrapping capacities that are no longer in use is not clear. The best known evidence for changes in the sensitivity of the child to distinctions in the input is the attested restriction of the child's segmental discrimination capacities to the phonological contrasts of the target (Werker & Lalonde 1988).

In addition to the dependency on the perceptual and representational capacities of the child in the different linguistic and non-linguistic domains, success of bootstrapping strategies will also depend on the availability of information processing capacities like memory and attention which are necessary to integrate the information extracted from the input into the learning mechanisms. Thus, rule formation on the basis of distributional learning probably puts particular demands on memory because of the necessity to keep track of the relevant co-occurrence relations. The existence of such frequency effects in pre-linguistic children points to the importance of memory processes (e.g., Jusczyk, Luce & Charles-Luce 1994). Consequently, changes in the bootstrapping capacities of the child may also be the result of changes in her information processing capacities, i.e., changes in memory and attentional resources, like, for example, changes in (short term) auditory memory or in the capacity of the child to coordinate her eye gaze with the eye gaze of the caretaker (e.g., Adams & Gathercole 1995; Baldwin 1995).

In order to understand the acquisition process, it is crucial to ask to which extent (and how) the child uses the information accessed in the input in her rule learning mechanisms (via bootstrapping mechanisms). The fact that the child is

sensitive to a certain property of the input which may be relevant from a theoretical perspective for the acquisition of a particular aspect of linguistic knowledge does not yet mean that she actually uses this information to acquire this knowledge.

Last but not least, we also have to reckon with the fact that all the capacities and the related processes mentioned so far may be affected by changes in the biological, neurophysiological environment in which they are embedded, and which in turn will also be affected by the perceptual and cognitive processes supported by it. Thus, the assumption that certain processes like the processing of closed class functional elements are subject to an increasing degree of automatization may be the expression of changes in the underlying brain structure (e.g., Friederici 1995). Another effect of maturational processes in the brain may be the existence of critical periods for the acquisition of specific aspects of linguistic knowledge.

The main aim of the present collection of studies is to contribute to the clarification and understanding of the questions and issues mentioned above. One important aspect is the interdisciplinary and cross-linguistic approach taken. Apart from experimental studies, the study of the acquisition of different languages, which differ only minimally in some well-defined respect, is a powerful tool for collecting evidence about the structure and interaction of bootstrapping mechanisms.

The present studies should both challenge and stimulate the efforts in related areas of research which are only marginally represented by these two volumes, like the increasingly active field of modelling of acquisition processes, the study of the interaction between general cognitive and linguistic development, the reflection on general models of language development, and especially the study of developmental language disorders. If, as we mentioned in the beginning, and as shown pervasively in the research on language acquisition in the last years, the decisive steps into language are taken during the first two years of life (made on the basis of the powerful bootstrapping capacities displayed by the child), it seems more promising to investigate the hypothesis that it is deficiencies in the bootstrapping capacities that largely contribute to the emergence of developmental language disorders.

For the study in the origin of language disorders, the importance of getting a clearer picture of the contribution of the different bootstrapping mechanisms and their interactions with normal language development becomes more and more clear. As mentioned before, the relative strength of the contribution of the different bootstrapping strategies for the extraction of language-specific regularities from the input seems to change over time. What we do not yet know is how

much development differs across subjects and how much deviance from the general course is tolerable without constituting a risk for successful language acquisition. In order to find out where the potential risks for the emergence of language disorders lie, it is necessary to compare the language development of unimpaired and language-impaired children over time. Initial results from current longitudinal studies in impaired and unimpaired language acquisition point to the fruitfulness of this approach (e.g., Benasich 1998; Lyytinen 1997). Longitudinal data is also needed to answer the question of which of the child's early linguistic and non-linguistic capacities underlying the bootstrapping mechanisms are innately determined and which are rather the result of epigenetic processes.

The papers contained in the two volumes are organized into five chapters. Chapter one concentrates on the prerequisites of early word learning. In his paper **Jusczyk** discusses the beginnings of word segmentation abilities at around 7 to 8 months of age. He presents evidence that English children use mainly prosodic cues with a preference for trochaic rhythmical patterns at the beginning but also benefit from phonotactic constraints, allophonic cues and distributional regularities from very early on. Furthermore, he reviews findings on the detection of function words in the input as an aid for the development of syntactic knowledge.

Echols reports further evidence for a trochaic segmentation strategy in English children. Moreover, she argues that perceptually salient syllables are those syllables in the speech stream infants are especially sensitive to. Besides stressed syllables final syllables have a high degree of perceptual saliency. She presents findings according to which final syllable lengthening is more pronounced in child-directed speech than in adult-directed speech. This fits with production patterns where stressed and final syllables are more likely to be included in the speech of one-word speakers than unstressed nonfinal syllables. This saliency pattern could also contribute to the tendency to extract trochaic feet from the input.

Fisher and Church discuss another open question with regard to lexical processing: namely the question how the initially rather poor word recognition abilities of young children develop into the efficient and rapid recognition skills found in adults. Differences in processing as well as in lexical representations are discussed as potential sources for these differences between children and adults. In a series of experiments the authors found evidence that basic word identification processes of preschoolers resemble those of adults. On the basis of these findings it is argued that the learning mechanisms that children use to create lexical phonological representations are the same as those mechanisms that create long-term auditory word priming in adults, i.e., a mechanism that continu-

ally updates the representations of the sound of words to reflect ongoing auditory experience.

Bernstein Ratner and Rooney provide evidence that certain structural properties of child-directed speech facilitate the early stages of word learning, especially the segmentation of the speech input in word like units. Their analysis of 10000 utterances spoken to children between 13 and 20 months of age shows several features that might assist children in solving the segmentation problem, namely a high proportion of very short utterances with many repetitions of lexical items and syntactic frames. Along with the demonstrated abilities of young children to use input information these specific input characteristics might support early language acquisition.

With the study by **Gleitman and Gleitman** the focus of the discussion changes to the semantic aspects of the acquisition of the lexicon: they ask how word meanings are learned and how word meanings function in the semantics of sentences. They argue that one potential source for the learning of word meanings lies in the child's capacity to match the occurrence of words with the scenes and events that accompany the words in adult-to-child interactions. Furthermore, within the syntactic bootstrapping account language internal contextual information is assumed to provide another powerful source of information on word meaning. Some experiments with adults reveal that these different sources of information might be relevant for the acquisition of the meaning of different word classes: given only extralinguistic context of a word use by video scenes without tone adult subjects were much better in identifying the meanings of nouns as compared to verbs. Verb identification abilities were better giving the subjects sentence structures in which only the grammatical morphemes appeared and all lexical morphemes were replaced by nonsense syllables. In language acquisition these different information sources for different word classes might be related to the initial dominance of nouns in children's production.

Fernald, McRoberts and Swingle focus on the developmental changes in word comprehension during the second year of life. They report findings that the speed and the accuracy in recognizing familiar words increases significantly within this period and that children from 18 months on already show the features of incremental processing which are found also in adults. They argue that these changes may reflect changes in the nature of lexical representations as well as changes in general perceptual and cognitive processing abilities.

McKee and Iwasaki argue in a similar direction on the basis of production data. Within the framework of a model of lemma-driven syntactic processing they point out that the misuse and the missing of closed-class elements in children's production data may have several reasons: it could either result from

incomplete linguistic knowledge or from a deficient processing system that put this underlying knowledge into actual utterances. A critical feature for distinguishing between these alternatives is the consistency with which a pattern of misuse appears: a deficient processing system allows for more variability than lack of linguistic knowledge. Based on data on the acquisition of Japanese they show the relevance of this criterion.

Chapter two focuses on the development of early syntactic knowledge. In the first paper **Gerken** argues that one of the main tasks of future research is to build the bridge between input features and the acquired system in the domain of syntax. She focuses on the question which input cues might help the child to detect phrase and clause boundaries to find out about syntactic structure and syntactic categories. Besides mentioning prosodic cues she draws the attention to the importance of the processing of grammatical morphemes which could signal phrase and clause boundaries and could also be used to assign a syntactic category to adjacent words. She points out that the recent findings on the richness of the signal and the high sensitivity of infants for distributional properties of the input should shed new light on the discussion of the logical problem of the acquisition of syntax.

Golinkoff, Hirsh-Pasek and Schweisguth follow the line of Gerken arguing that the sensitivity to grammatical morphemes may contribute in important ways to the acquisition of syntax. They report findings of an experiment that support the assumption of an early sensitivity to grammatical morphemes: children between 18 to 20 months of age react differently to correctly inflected verbforms than to verbs with a “wrong” inflectional ending or a nonsense syllable replacing the inflection.

A slightly different perspective on possible input cues to the acquisition of syntactic categories is taken in the paper by **Durieux and Gillis**. They discuss several phonological features of a word itself that could be used to predict its syntactic category. They show that the integration of several phonological cues (stress, length, vowel and consonant quality among them) leads to good predictions of the syntactic category for English as well as in Dutch words. But it is still an open question whether infants can benefit from these cues in natural language acquisition.

Within the framework of the parameter setting model for acquisition of syntax **Guasti, Nespor, Christophe and van Ooyen** argue that children use the correlation of prosodic and syntactic structure — especially the rhythmic pattern within the intonational phrase — to find out whether their target language is head initial or head final.

Following this idea **Höhle, Weissenborn, Schmitz and Ischebeck** present

the results of a series of studies on the sensitivity of German children to word order regularities. They found clear prosodic differences between sentences involving head-complement constructions as compared to head-modifier constructions. This may help children to discriminate between complements and modifiers. Furthermore they present evidence, that children of 20 to 21 months of age may discriminate grammatical vs. ungrammatical word order if the difference in grammaticality correlates with differences in prosody.

Penner, Wymann and Weissenborn discuss an apparent asymmetry in the speech of children learning German between systematic violations of the canonical strong-weak pattern in speech production and target consistent word order which is assumed to be acquired on the basis of the knowledge of the stress pattern of the target. They explain the delay at the production level by the fact that intricate interface data force the child to resort to intermediate under-specified representations of phonological phrases.

Chapter three focuses on the interaction between prosodic and morpho-syntactic factors in the process of development of linguistic knowledge. **Demuth** reports an account of syllable omission and the development of grammatical morphology in early mono- and multimorphemic utterances of a Spanish child on the basis of a theory of Prosodic Constraints. She shows that these constraints are different from those found in English. The main result is that the appearance of grammatical morphology depends on the level at which grammatical morphemes are prosodified, with lower level elements being acquired before higher level elements. She concludes by pointing out possible implications of her approach for the study of individual differences, for the identification of children at risk of language delay, and for a more general constraint-based approach to language acquisition.

In a similar vein **Lleó** shows in her contribution that the fact that Spanish determiners are acquired way before their appearance in the language of German speaking children is explained by the different prosodic structures of the article in the languages concerned. These prosodic differences explain that the Spanish article appears already on single nouns whereas in German the article is first realized within larger structures. These results provide further evidence for the importance of the prosody-syntax interface for the acquisition of grammatical knowledge.

This importance is confirmed by the findings of the study by **Freitas, Miguel and Hub Faria** on the acquisition of codas in European Portuguese. They show that the acquisition of elements of syllabic structure like codas may differ depending on the grammatical features encoded by them in the target language. Thus, codas with fricatives encoding plural are acquired earlier than

one would expect on the basis of prosodic factors alone. This finding opens up new perspectives on the intricate interaction of different linguistic levels in development, and especially draws attention to the fact that from very early on abstract grammatical features must be taken into account.

Fikkert discusses data from the development of the prosodic structure of monomorphemic and compound nouns in Dutch. In this domain, contrary to a widely held view, it is not the case that simple structures are acquired earlier than complex ones. What she observes instead is that the acquisition of compounds guides the child in the acquisition of monomorphemic words consisting of more than one foot. Her analysis is formulated in terms of a parameter setting approach that assumes that parameters are set from an initial unmarked (default) value to the marked value when the required evidence is encountered in the input.

In his paper **Lebeaux** develops an account of how the properties of telegraphic speech in children can be explained as the result of a prosodic-syntactic tree mapping at the phonology-syntax interface. More specifically, he argues that telegraphic speech is derived as a consequence of the child computing structure with two representations: the syntactic one and the prosodic one. The child attempts to find the maximal alignment of these two structures by factoring out their discrepancies which had been introduced by generalized transformations operating on identical phonological and syntactic kernel structures.

Peters proposes a model for the development of distinct closed class lexical elements in English from an initial undifferentiated single protomorpheme occupying grammatical positions which the child is assumed to discover on the basis of their prosodic characteristics. The subsequent differentiation of this protomorpheme into three distinct classes (catenatives, auxiliaries, and modals) is the result of a gradual process of specification on the basis of growing information from phonological, semantic, and syntactic properties of the input.

In the last paper of this section **Strömqvist, Ragnarsdóttir and Richthoff** show on the basis of a particular cross-linguistic approach, namely the within-language group comparison (Danish, Icelandic, Swedish) that subtle differences in the configuration of function words in terms of frequency, stress, word order, and ambiguity have an impact on the course and structure of acquisition. They provide evidence that the child starts with stressed, more concrete (e.g., deictic) elements which may serve as templates for the acquisition of unstressed, functionally different (e.g., expletive) forms instantiating the developmental principle that new functions are first expressed by old forms.

Chapter four deals with neurophysiological aspects of language acquisition.

Molfese, Narter, van Matre, Ellefson and Modglin give an overview of changes found in ERP-patterns to linguistic stimuli in infancy and early childhood. In the domain of sound discrimination ERPs reflect behavioral findings very closely, including categorical perception and the emergence of the discrimination of different speech cues at different times. Changes observed during early language development include changes in temporal as well as in topological features of the ERPs. If words are used as stimuli ERPs reflect whether the words are rated as known or as unknown by the child. Furthermore, the paper discusses findings that ERPs may be used as a predictor for later language development: longitudinal data suggest that children who differ in their language abilities at three or five years of age already differ in their ERPs to speech at birth.

Friederici and Hahne focus on ERP components that correlate with the processing of syntactic information. They report findings that adult-like temporally different ERP patterns to semantic and syntactic violations can be found already in children from 6 years on but that especially the component related to a first-pass syntactic parsing mechanism is slowed down in the children. On the basis of a three stage model for language comprehension they argue that the parsing routines of the children are similar to those used by adults but have not yet reached the highly automatic status found with adults.

St. George and Mills take a closer look at correlations of changes in ERP patterns and changes in word knowledge. They report that the vocabulary spurt goes hand in hand with dramatic changes in the topology of the ERP-pattern of known and unknown words. They recorded ERP responses to open and closed class items during the second to the fourth year of life linking the acquisition of lexical knowledge and the acquisition of syntax. While initial responses to open and closed class items are the same, at around 28 to 30 months of age the ERPs start to be different for the two classes with a greater lateralization to the left hemisphere for the closed class than for the open class. This difference is even bigger for older children. Furthermore, the appearance of these changes seem to be linked to language abilities and not to chronological age.

Chapter five groups together studies on additional perspectives of language acquisition addressing questions of methodology, the nature of linguistic primitives, and the development of bird song as compared to human language acquisition. **Plunkett** summarizes the recent contributions of cognitive neuroscience, experimental psycholinguistics, and neural network modelling for our understanding of how brain processing, neural development, genetic programmes, and the environment interact in language acquisition by focussing on the areas of early speech perception, word recognition and the acquisition of inflectional morphology. Each area demonstrates how linguistic development can be driven

by the interaction of general learning mechanisms, highly sensitive to particular statistical regularities in the input, with a richly structured environment.

Bierwisch addresses the question whether the primitives of linguistic knowledge, i.e., phonetic, semantic, and formal, morpho-syntactic features, are a prerequisite or a result of the acquisition process. He concludes that they must basically be considered as derived categories which emerge from the accommodation of actual data according to general principles of representation provided by Universal Grammar which may be interpreted as genetically fixed dispositions.

On the basis of the analysis of trajectories of song development in nightingales **Hultsch and Todt** provide evidence that, in addition to interactional variables and a predisposition to sensitive phases, the development of bird song shares learning mechanisms with human language development like the hierarchical organization of memory, the chunking of information into distinct units, e.g., songs vs. sentences, and the sensitivity to contextual factors. These similarities have to be contrasted with the structural differences between bird song allowing only for a limited number of meaningful elements, and human language which provides the speaker with the possibility of an unlimited number of novel meaningful utterances.

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