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Language Acquisition

Chapter 1: How Language Comes to Children

"The ultimate issue in linguistic theory is the explanation of how a child can acquire any human language." Thomas Roeper in Introduction to Hyams (1986).

"The capacity to learn language is deeply ingrained in us as a species, just as the capacity to walk, to grasp objects, to recognize faces. We don't find any serious differences in children growing up in congested urban slums, in isolated mountain villages, or in privileged suburban villas", Dan Slobin, *The Human Language Series,* 1994 (quoted from Fromkin and Rodman).

1.1. Two Points of View

Language Acquisition Device (LAD) is

a **general, cognitive** mechanism — or — a **specific, modular** mechanism

a **general, cognitive** mechanism	a **specific, modular** mechanism
Psychology	Linguistics
Skinner	Chomsky
connectionism	(recently convergence of opinions)
general program specialized for certain input	LAD = **specific, genetic program**

Pinker 1994:18.*The Language Instinct*. Pelican.London.

Language is not a cultural artifact that we learn the way we learn to tell time.... Instead, it is a distinct piece of biological makeup of our brains. Language is a complex, specialized skill, which develops in the child spontaneously, without conscious effort or formal instruction, is deployed without awareness of its underlying logic, is qualitatively the same in every individual, and is distinct from more general abilities to process information or behave intelligently. For these reasons .... I prefer the admittedly quaint term "instinct".

Mehler and Christoph 2000: "….language, a species specific aptitude, seems to be acquired by selection from a set of innate dispositions".

By looking at the areas of semantics, syntax, phonology and morphology we have seen that language is extremely complex. And yet small children, who cannot dress on their own, cannot find their way home, and cannot add 2 and 2, are able to conjoin sentences, form relative clauses and use the phonological, morphological, semantic and syntactic rules of their language. The most striking fact about this early ability to use language is that children are not taught their first language but pick it up easily through positive input.

1. 2. The Logical Problem of Language Acquisition

Children acquire language

- without explicit teaching
- on the basis of positive evidence (what they hear)
- in a limited amount of time and under varying circumstances
- in identical ways across different languages

1.2.1. Acquiring a language without explicit teaching and on the basis of positive evidence

Parents do not teach their babies the rules of language. There may be some correction but this is unsystematic and children seem to ignore it. English children say *goed*, even if they are often corrected and asked to say *went*. Irregular verbs, other morphological difficulties or the right pronunciation and forms of words are sometimes corrected by the parents: if the child insists on saying *'nana*, parents will occasionally correct to *banana*. Corrections on the syntactic level are much rarer and totally misinterpreted by children.

(1) Mc Neill (1966:69)

CHI: Nobody don't like me.
MOT: No, say 'nobody likes me'.
CHI: Nobody don't like me.

(eight repetitions of this dialogue)

MOT: No, now listen carefully: say 'nobody likes me'.
CHI: Oh, nobody don't likes me.

The mother aims to correct the double negation which is not allowed in Standard English. The child fails to notice this and finally picks up the 3rd person *–s* of *likes*, uses the form incorrectly, however. (There is another example in Fromkin and Rodman, p. 330).

Such examples show two things: Parents do not try to explain or give a rule ('Do not use two elements expressing negation'), the only thing they might do is provide the correct form and expect the child to imitate this. They might also point out that the form used by the child was wrong. Note that the initial 'No' is a metalinguistic comment by the mother and is the equivalent of the star used in linguistics. Note further that this kind of information, the star, is what the child does not understand.

Linguists use both kinds of information to formulate the rules of a language: the correct forms they find and the forms they know to be incorrect. If a starred sentence can be derived by the rules, something must be wrong with the rule system. A starred sentence thus provides the linguist with 'negative evidence' – evidence of what does not occur. Positive evidence is what is possible in a language and is what the child hears (unless the parents are sloppy speakers or are not native speakers at all and make a lot of mistakes).

There is a lot of speculation whether children might or might not have access to 'negative' evidence. Parents' disapproval, failure to understand, corrections, expansions of their child's utterances, or the frequency of their reaction to their child's speech have been assumed to provide the child with hints as to the incorrectness of an utterance. However, such evidence is not provided to all children on all occasions (there are cultures where adults do not address children at all), it is generally noisy (see (1)) and not systematic enough to be sufficient. So the general consensus is that children are blind to negative evidence and acquire language through exposure to positive input only.

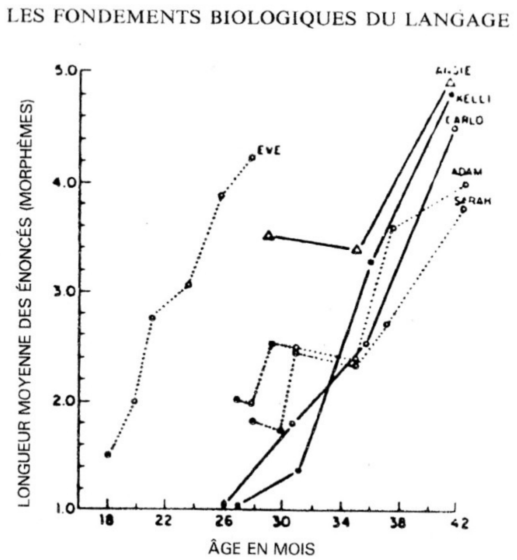
1.2.2. Acquiring language in a limited amount of time under varying circumstances and in identical ways across languages

By the age of 5 children have mastered most of the constructions of their language, even if their vocabulary is still growing. By the age of 3, sentences are well formed, verbs are correctly inflected for present and past tenses and subordination is used consistently. Roughly in the space of one year (from the occurrence of the first two word combinations at the age of about 2 years till about the third birthday), the basic syntactic constructions are acquired and used. Given the complexity of the task, this is amazingly fast. Another interesting fact emerging from more and more research on language acquisition is that though variability exists in the rate at which a construction may be acquired or vocabulary grows in a child, "individual variation is less striking than similarities in development" (Bishop and Mogford 1993:22).

Language acquisition is robust and uniform in that children acquire language even if they do not seem to have all the necessary requirements at their disposal.

Blind children acquire language and vocabulary at about the same rate seeing children do – though a pointing gesture to identify objects cannot be used.

- 'Wild' children who have suffered extreme deprivation and sometimes have not had any language input at all, are often able to acquire language – if they are recovered during the 'critical period'.
- Children of deaf parents acquire language given a minimal input of 5-10 hours of spoken language per week.
- Deaf children may have difficulties acquiring oral language but go through the normal stages of language acquisition if exposed to a natural sign language.
- Children acquiring different languages go through the same stages.



- blind children (Angie, Kelli, Carlo)
Landau & Gleitman ´85

…. seeing children (Adam, Eve, Sarah)
Brown & Bellugi ´64

Figure 1

From Mehler and Dupoux 1990, p. 195

At around 6-8 months all children start to babble – produce repetitive syllables like '*dadada*'. At about the same time deaf children produce the equivalent to babbling in repeating certain sign sequences. At about 10-12 months children speak their first words and at around 20-24 months they start to combine words. In the third year of life children in many languages overregularize the past tense of verbs (*wented, holded,* see Fromkin and Rodman p. 328), use infinitives or stem forms instead of inflected verbs and omit articles and the subjects of sentences. This phase is sometimes called the 'telegraphic speech' phase. By the third birthday children are usually beyond these 'errors'. Up to the age of 6 years, children in many languages have difficulties with pronouns and can interpret the 'him' in 'John saw him' as referring to John. This list of similarities can be prolonged and shows that acquisition is rather uniform across individuals, circumstances and languages.

1.2.3. The stages of language acquisition

We keep in mind the big milestones:

- from birth to about 6 months – so called prelinguistic stage
- at around 6-8 months onset of babbling (first manifestation of phonology)
- at around 10-12 months first words
- at around 20-24 months onset of the two-word stage (first manifestation of syntax)
- till about 36-40 months: so called 'telegraphic speech'

1.2.4. The logical problem of language acquisition: poverty of stimulus

The obvious question to ask is how do children manage to acquire language so fast and without getting hopelessly lost. The generative answer to this question was to postulate an innate language module called 'Universal Grammar' – UG. As early as 1965 in his Aspects model, Chomsky claimed that "... knowledge of grammatical structure cannot arise by application of step-by-step inductive operation..." (Chomsky 1965, p. 57).

We will investigate what 'inductive' operation means in this case and show why such operations cannot solve the basic problem: the poverty of the stimulus. There are three arguments connected with the idea of the 'poverty of the stimulus'.

- the input is finite, the output is potentially infinite
- the input is incomplete, the child arrives at correct forms and rules
  (parents do not always produce acceptable sentences,
  see also the language acquisition of blind children or the formation of creoles)
- there are language phenomena for which there is no (simple) direct positive evidence

Whereas the first two arguments are rather obvious, it is the third which poses the real problem for any theory which proposes language acquisition on the basis of imitation or analogy. Actually, the problem is rather simple: We have seen that rules are structure dependent and a structural analysis is not provided in the input. Consider *yes-no* questions.

(2) a. The book is dull.
    b. Is the book dull?

First attempt at rule formation: Front the third word.

(3) a. The book on the shelf is dull.
b. *On the book the shelf is dull?

A rule permuting the linear order of elements is not sufficient. We need at least access to categorial information (DP, Aux etc.).
Second attempt at rule formation: Invert the first nominal group (DP) and the first auxiliary.

(4) a. The book which is on the shelf is dull
b. *Is the book which on the shelf is dull?

You need a structural representation which allows to identify full constituents. Note: all our constituent tests made use of the fact that operations apply to constituents. Operations are structure dependent, you cannot read off structure from the linear order of words in an utterance. In fact, the same linear orders may give rise to two possible structures and so allow structural ambiguity: *Bob saw the man with the glasses*. Mere input does not give information about such ambiguities.

Another set of 'rules' of grammar which is not directly obvious from the utterance itself is the set of rules regulating the interpretation of pronouns, anaphors and lexical DPs.

(5) a. John is touching himself
b. *John is touching him (impossible if *him* is referring to *John*)
c. *The man is touching the man.

Rule of 'in the same clause'?
An anaphor must corefer with a DP in the same clause
A pronoun cannot corefer with a DP in the same clause

(6) a. John says that he is tired
b. *He says that John is tired

Rule of "linear precedence" + "same clause"?
A pronoun cannot corefer with a DP in the same clause and it cannot corefer with a DP which it precedes.

(7) When he was arrested, John had his wife with him.

Again you need access to structure – which is the adjunct, where is it adjoined, which element is higher in the (D)- structure. Hierarchical structure does not necessarily coincide with the linear order. The structural notion needed to describe the facts of pronoun interpretation is the notion of c-command, see the exercises.

Note also that structural information is essential in the case of 'silent' elements.

(8) a. Bob saw him, and John did too.
(8) b. Bob saw Bill, and he did too.

There are silent pronouns in the cases of VP-ellipsis in (8a) and (8b) and these are interpreted by the same rules that apply to overt pronouns. If these elements are not even overt, rules cannot be read off the input. (See Thornton and Wexler 1999).

1.3. Where Does Knowledge of Language Come From?

How does an adult speaker know that a sentence is

- ill formed (see (9))

(9) *John went often to school

- cannot have a certain meaning (*he* in (6b) cannot refer to John)
- or that it is ambiguous?

Several hypotheses have been advanced. The most likely and most discussed are the following: Learning through **imitation**, through **reinforcement,** by **association** procedures or **analogy**, or with the help of an innate mechanism called **Universal Grammar (UG).**

1.3.1. Learning through imitation

Children learn language by imitating what adults say, by repeating what they hear. However, several facts show that there is no necessary similarity between input and output.

- A very high proportion of parent's utterances are questions or commands. Children's first utterances, in contrast, are declaratives.
- Children continually produce novel utterances. They even produce words and utterances they cannot have heard:

  goed, wented, singed, - morphological **overgeneralization**

(10)	a. You finished me lots of rings	Adam	4.11
	b. Jay said me no	Ross	2.8

case of **overgeneralization** of subcategorization

(11)	What do you think what the baby drinks	MA	3.3

Note that (11) is not an overgeneralization because such a structure does not occur in English and there is no similar structure which could serve as a model. However, such an utterance is not a fortuitous error. It occurs systematically if you elicit this type of questions from children between the ages of 3.6. and 5.0. The important point is that such structures exist in other languages and thus reflect a possible human language rule.

Children do not learn language by imitation (only)!
(See Crain and Thornton (1998) for full arguments on this point).

1.3.2. Learning through reinforcement

In the behaviorist tradition learning language is nothing special but just an instance of learning by reinforcing the contingent association of stimulus-response patterns. This learning mechanism is supposed to be a general purpose device in animals and in humans.

However, learning through reinforcement cannot describe the acquisition of human language and the attainment of language competence. Again, children produce sentences they have never heard before. It follows that no reinforcement can have been provided.

Moreover, it is not quite clear what sort of reinforcement will drive the acquisition of grammar. If it is simply the success of being understood, then reinforcement cannot be the driving force. Parents react (mostly) to **what** children say, not **how** they say it. Consider the following exchange (see Guasti 2002:12):

(12) Adam: Where penny go? 2.5
Mother: I don't know.

Adam: Where penny go? 2.5
Mother: Didn't you drop your pennies on the floor?

Adam has been understood and rewarded with a communicative exchange helping him to recover his pennies. If this sort of reinforcement is taken by the child as a sign for having uttered a 'good' sentence, then Adam will never learn to ask questions correctly.

Note also that negative reinforcement in the form of corrections will be misunderstood by the child (see (1)).

1.3.3. Learning through association

The most radical hypotheses about learning language claim that there need not be any symbolization, no learning of rules and thus no assignment of structure at all. Such hypotheses claim that language learning happens by associations of input and output patterns. The demonstration that such learning is possible is usually done by computer simulations of neural networks.

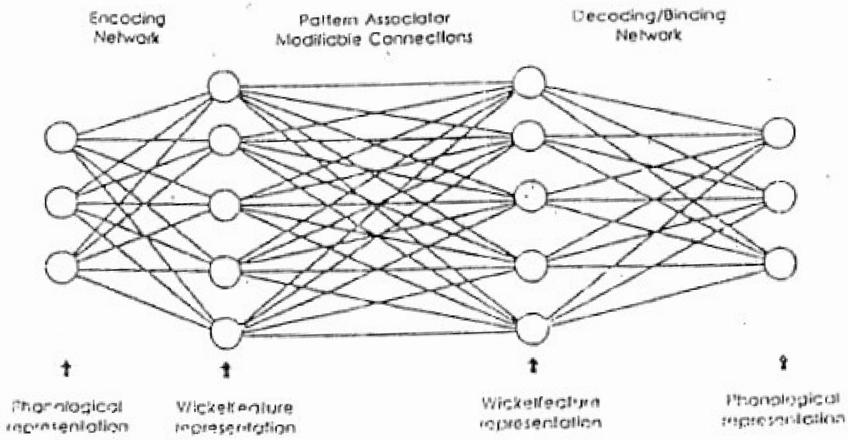
Artificial neural networks assume that there are several layers of interconnected processing units as we find them in the brain which either emit a pulse or don't. The crucial layers are the input layer and the output layer. They contain input and output units which emit a pulse according to their activation state. They are connected by modifiable, weighted links. The activation state is calculated by a function which takes into account the strength of the incoming signal according to the weight of the connection and the actual activation state of the unit. Emission of a signal also depends on a threshold value: the activation measure must be greater than this threshold for the unit to emit a signal.

The machine learns by being fed certain pairs of input and output. Lets assume a model in the process of learning the past tense. Whenever input unit 'walk' is activated, output unit 'walked' is activated. Whenever input unit 'sing' is activated, output unit 'sang' is activated. The input unit 'walk' has a lot of possible links to different output units. By the repeated occurrence of the input-output pair 'walk-walked', the link to the unit 'walked' will be reinforced and weighted so that it will be chosen each time the input 'walk' comes in. After this learning phase the network can generalize to new stimuli belonging to the same class. So the input 'ring' will lead to the output 'rang' by association to 'sing-sang' and the input 'talk' will lead to the output 'talked' by association with 'walk-walked'. Differences between regular and irregular verbs vanish (up to their statistical frequency) and rules are not necessary anymore, they are represented by various activation patterns of input and output units. (See Rummelhart and MacClellan 1986, Plunkett and Marchman 1993).

Characteristics of Neural Nets:

"no explicit rules, only a set of neuron-style units which stand for trigrams of phonetic features of the stem, a set of units which stand for trigrams of the phonetic features of the past form, and an array of connections between the two sets of units whose strengths are modified during learning" (Pinker and Prince 1988:73).

Figure 1: The Rumelhart-McClelland PDP Model



Networks are thus characterized by three major factors:
- the threshold values of the units
- the number of layers
- the functions which alter the weight of connections locally.

" We have, we believe, provided a distinct alternative to the view that children learn the rules of English past-tense formation in any explicit sense. We have shown that a reasonable account of the acquisition of past tense can be provided without recourse to the notion of a "rule" as anything than a description of the language. We have shown that there is no induction problem. The child need not figure out what the rules are, nor even that there are rules ...We view this work on past-tense morphology as a step toward a revised understanding of language knowledge, language acquisition, and linguistic information processing in general." (Rumelhart and McClelland 1986b:267f)

Adapted from Hamann 1997 (Manuscript version of H 2002)

A surprising result emerging from such modelling was that machines could overregularize the past tense just like children do. The trained machine would produce 'holded' in analogy to 'folded' and 'molded'. However, children's overregularizations are not only phonology based. There is evidence that children overregularize the main verb 'do' in *I doed it,* but never overregularize the auxiliary 'do': We never find *Doed you come*?

More recently it has been suggested (Pinker 1997) that regular morphology is rule based but that irregular morphology might well be learned by association. See also Tomasello (2000) for the suggestion that subcategorization frames are learned by association. However, Pinker and Prince (1998) pointed out that important phonological generalizations (holding cross-linguistically) are lost by the move away from a symbolic rule. They mention specifically the rule of 'voicing assimilation' found in past tense formation but also in the formation of plurals. (See exercises).

Even if we concede that much of language learning is by association and statistical evidence plays an important role, there remains the problem that language learning is possible even based on totally degenerate input.

Deaf children of deaf parents who learned sign language late will receive degenerate input in that subordination and functional elements are often missing in their parents' sign language. Such children will develop a sign language containing subordination and functional words, however. Note also that recently a group of researchers could document the birth of a native language in a community of deaf Nicaraguan children. These spontaneously created a signing system which has all the characteristics of a human language and is not just a communication system like morse. (Senghas et al.)

A similar case is provided by pidgins and creoles. Pidgins provide a form of communication based on the vocabularies of two or more languages without much grammar (functional morphemes). They often originated on plantations and slave colonies in the nineteenth century. Once a pidgin has native speakers – the children of speakers of such a pidgin – it quickly develops into a full blown language, a creole. Creoles, unlike pidgins, have function morphemes and a more elaborate structure (see Bickerton 1984). Clearly, connectionist models cannot capture such a spontaneous creation of language, given the strict association mechanism they use.

1.3.4. Universal Grammar

On the back-ground of the logical problem of language acquisition and the poverty of the stimulus, the only hypothesis not invalidated by empirical evidence seems to be the assumption of some innate linguistic ability.

Support for the idea of a sort of Universal Grammar comes from the fact that languages all over the world resemble each other in certain respects and it would be rather surprising if such similarities were not determined by the neuro-biology of the brain. In the Chomskyan tradition, UG is supposed to be rather rich in containing universal constraints on language. This explains why language acquisition is possible despite all variations and limitations in the learning conditions, why it can happen so fast, and why it proceeds in similar stages over individuals and languages.

Of course, not all linguistic knowledge is innate!

We must allow for variations, especially the learning of different languages. The answer to this problem is to think of UG as a set of **principles**, common to all languages, and a set of **parameters** which are set differently in different languages and will be set by exposure to the relevant input. Some languages will allow to omit the subject (Italian, Spanish), others do not (English, Spanish). Some languages will raise the verb to pick up inflection (French, Italian), others will lower the inflection to the verb (English). The child will have to select the parameter setting consistent with the language input he or she receives (English, French, Italian). So language acquisition is a selection process from universally given possibilities (parameters) guided by universal constraints (principles).

Let's now look at example (11) from the perspective of UG. In English, only (11') is a well formed sentence.

(11') What do you think the baby drinks.

Note that the question does not ask what you think, but what the baby drinks in your opinion. *What*
therefore asks for a constituent of the lower clause.
In some dialects of German (12) is a good sentence.

(12) Was$_i$ glaubst du was$_i$ das Baby trinkt t$_i$
(12') What do you think what the baby drinks

The English version of (12) is (12') and this is exactly what children say. The point of this is that children use a structure which is not in their target language, but which is permitted by general principles of grammar – otherwise it could not occur in a dialect of German. So children's systematic errors are not evidence for wild grammars and wild hypothesis formation but show that these errors are UG constrained. The structures in question may not be possible in the target language due to the final parameter settings in that language, they are possible from the point of view of the universal principles, however, and are instantiated in other languages. In this sense children's productions never lie outside of what UG permits.

Support for the innateness hypothesis also comes from research on the **critical period** for language acquisition. Recall, that we have seen evidence from brain imaging that there are critical period effects for acquiring phonology, morphology and syntax. Behavioral evidence was provided by studying the linguistic performance of 'wild' children or deaf children provided with hearing aids late in life and of second language learners. The existence of such a critical period for language acquisition was important because genetically determined biological systems like vision usually show a critical period.

Chapter 2: What Babies Know and Do

2.1. A Prelinguistic Stage?

It has long been accepted that the first sounds a baby makes are not language related but stimuli driven noises expressing discomfort or contentment. In this sense, in that there is a stage where there are no language sounds, researchers have spoken of a prelinguistic stage.

However, recent psycholinguistic research has shown that during this stage infants are highly sensitive to speech sounds. So even if there may be a prelinguistic phase from the point of view of production, there seems to be no such phase from the point of view of perception.

<u>4-8 days</u> of age:

babies prefer language to other noise,
distinguish their mother tongue (independent from speakers)
distinguish (certain) foreign languages

<u>4-8 months</u> of age:

babies prefer pauses at syntactic boundaries to random pauses;
babies distinguish syllables, but not chains of consonants;
babies can distinguish phonemes (perception of categories); /pa/ > /ba/
babies distinguish the phonemes of the universal inventory, narrow this down to the inventory of their native language;

experimental techniques:

head turning times; frequency of non-nutritive sucking: HAS;

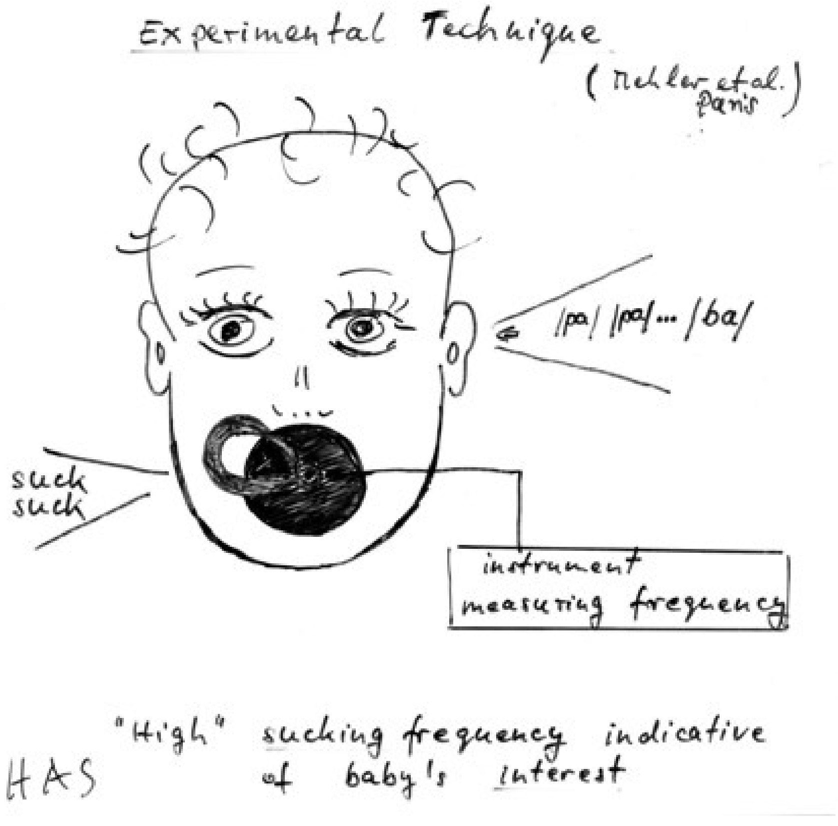


Figure 1

So even before babies begin to babble – produce speech sounds – they are highly sensitive to speech and language. From this perspective there is no prelinguistic phase. Babies seem to be biased to pay attention to speech stimuli.

It is interesting that initially, babies are sensitive to any acoustic stimulus that has a phonological value in some human language, not only to acoustic stimuli relevant in the language they are exposed to. This is so because babies are potential native speakers of any human language and therefore the process of acquisition can be seen as a selection of possibilities presented in the language of the environment from a universal inventory.

2.2. Language Discrimination

Imagine a child growing up in bilingual environment. We know that – given no a priori cognitive problem – children are well able to learn both languages simultaneously (bilingual first language acquisition). This ability requires an early discrimination of languages.

Many studies have shown that infants can discriminate two languages or a foreign language from the language of their environment. Studies were careful to use the same speaker for both languages.

Table 1

Pairs of languages used in studies of discrimination between the native language and a foreign language. Unless noted otherwise, the pairs of languages were discriminated.

Languages discriminated	Infants' native language	Age at testing	Source
French-Russian	French	4 days	Mehler et al. 1988
English-Spanish	Spanish, English	2 days	Moon, Cooper, and Fifer 1993
English-Italian	English	2 months	Mehler et al. 1988
English-Japanese	English	2 months	Christophe and Morton 1998
English-French	English	2 months	Dehaene-Lambertz and Houston 1998
English-Spanish	Spanish	4 months	Bosch and Sebastián-Gallés 1997
English-Catalan	Catalan	4 months	Bosch and Sebastián-Gallés 1997
Spanish-Catalan	Spanish	4 months	Bosch and Sebastián-Gallés 1997
Spanish-Catalan	Catalan	4 months	Bosch and Sebastián-Gallés 1997
English-Dutch (no discrimination)	English	2 months	Christophe and Morton 1998
English-Dutch	English	5 months	Nazzi, Jusczyk, and Johnson 2000

From Guasti 2003, p. 25

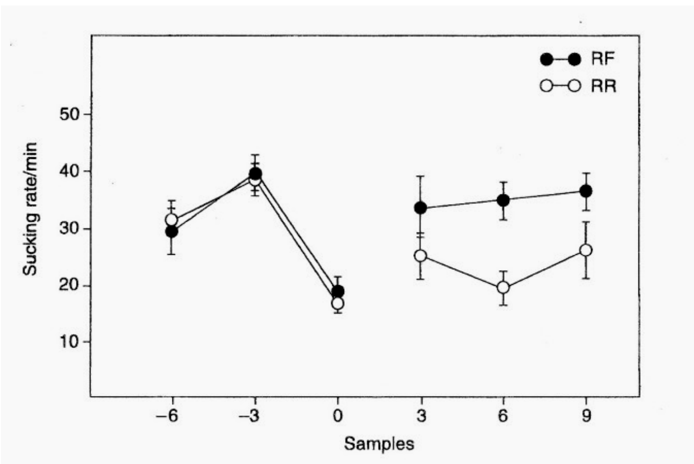


Figure 2

Sucking rate averaged over three consecutive samples during the habituation phase and the experimental phase of a study in which infant French learners heard utterances from Russian during the habituation phase. Group RF heard French during the experimental phase and group RR continued to hear Russian.

The next step was to see whether babies can also distinguish two foreign languages to exclude the possibility that four days exposure or in-uterus exposure to the native language has sufficed to familiarize the child with the special sound patterns of the ambient language. The results were extremely intriguing.

Four day old French babies can distinguish English and Italian or English and Japanese. So there must be some bias operative at birth which picks up certain acoustic signals relevant for such distinctions (intonation, vowel quality, syllables). It was therefore very puzzling but also revealing that French 4-day olds could not distinguish English from Dutch.

Table 2

Table 2.2
Pairs of languages used in studies of infants' discrimination between foreign languages. Unless noted otherwise, the pairs of languages were discriminated.

Languages discriminated	Infants' native language	Age at testing	Source
English-Japanese	French	5 days	Nazzi, Bertoncini, and Mehler 1998
English-Italian	French	4 days	Mehler et al. 1988 (reanalyzed in Mehler and Christophe 1995)
Dutch-Japanese	English	2 months	Christophe and Morton 1998
French-Russian (no discrimination)	English	2 months	Mehler et al. 1988
French-Japanese (no discrimination)	English	2 months	Christophe and Morton 1998
English-Dutch (no discrimination)	French	4 days	Nazzi, Bertoncini, and Mehler 1998

From Guasti 2003, p. 29

2.2.1. Crucial acoustic cues

In the search for the property which enables infants to make these distinctions, especially the group of Jacques Mehler in Paris ran a series of experiments modifying acoustic cues technically.

As it is unlikely that babies identify individual words of a given language, the search singled out other properties. The first idea is that babies react to some gross cue like mean energy of the signal, which is pitch. If you run a tape backwards you preserve such pitch properties (high frequencies) but you alter the prosody (intonation). Babies could not distinguish languages when the tapes were played backwards. This means that they do not react just to pitch qualities.

Babies could also make distinctions by recognizing segmental properties of a language (specific features or phonemes). So they were tested with low-pass-filtered speech – this is a process where only frequencies below 400 Hz are retained and all high frequencies are cut off. In low-pass-filtered speech, single sounds can no longer be identified, prosodic and other suprasegmental information like intonation and rhythm is maintained, however. The finding that infants succeed in discriminating languages under this condition shows that they do not rely on segmental but on some suprasegmental information like prosody or rhythm.

So prosodic information is sufficient for discrimination and one could ask whether it is also necessary. In a further experiment multi-syllabic words were extracted from a sentence and reassembled in a scrambled order. In this condition, segmental information is retained because the phonemes in the words stay the same. The prosody is destroyed, however, because words are transferred from places where they might have born tonic stress or where a fall-rise pattern indicated a syntactic boundary, to places where such stress patterns do not usually occur in a natural utterance. If phonemic information is enough, babies should not have any trouble to discriminate in this condition. If prosodic information is crucial, they should not be able to distinguish languages. The experiment showed that they cannot discriminate scrambled speech.

Note that this experiment additionally shows that what is crucial is prosodic information on the utterance level, not the word level. The latter is preserved if you just scramble the order of words.

Intonation or prosody therefore stands out as cue factor in the identification of different languages and as an acoustic cue infants use from early on to distinguish a foreign language from their ambient language or to discriminate between two foreign languages. It follows that there must be some very robust and reliable acoustic cues in prosody which infants are able to pick up easily.

2.2.2. Rythm-based language discrimination

Discrimination tasks require the baby to build a representation of the sounds of one language, then build a representation of the sounds of the other language and finally compare them. Given the above results, Mehler and his colleagues suggested that infants extract and build representations based on rhythmic properties – which are known to vary across languages.

(1) stress-timed languages: Dutch, English, German, Russian, Swedish
syllable-timed languages: Italian, French, Greek, Spanish
mora-timed languages: Japanese, Tamil

In stress-timed languages, listeners perceive a regular recurrence of stress, in syllable timed languages you perceive a regular recurrence of syllables and in mora-timed languages you perceive the recurrence of morae. These distinctions are not primitive properties but come about through the interaction of phonological properties of a language.

Stress-timed languages tend to have more syllable types and thus the interval between vowels is long and irregular. There is a large variability in the number of consonants per syllable, English has 16 syllable types and a maximum of seven segments per syllable. Moreover, heavy syllables tend to bear stress and light ones are unstressed, unstressed syllables tend to be reduced (schwa as a vowel or even syllabic consonants). So there also is a great variability in the duration of syllables.

In syllable-timed languages, the distance between vowels is shorter and there are fewer syllable types. Spanish has 9 syllable types, which contain at most five segments. (Remember the vowel- insertion rule for Spanish which serves to conform to this rhythmic property).

In mora-timed languages, the distance between vowels is even shorter as these languages have long vowels which correspond to two regular vowels. So vowels are perceived as occurring with great regularity.

The hypothesis put forward by Mehler and colleagues is therefore that infants concentrate on vowels and their pattern of occurrence. This is very likely as vowels are acoustically salient. So infants representations of speech as sequences of vowels should vary according to the rhythmic properties of the relevant languages.In (2) v stand for a light vowel and V for a heavy one.

(2) Stress timed: V Vv V VvV V
Syllable timed: V V V V V VV V
mora-timed: V V V V V V V V

This hypothesis predicts that infants can distinguish on the basis of these broad rhythmic properties and that languages with the same rhythmic properties should be classified as the same. So infants do not really discriminate languages at birth or at 4 days, they distinguish rhythmic classes of languages. Note also that this takes care of the puzzling result about Dutch and English. For a French child who is accustomed to a syllable-timed rhythm both these stress-timed languages should sound much the same. Other predictions are rather obvious. It is also indicative that 4 or 5 months old English babies can distinguish Dutch from English, which argues for the fact that by then more detailed properties have been acquired and the child has progressed to a finer distinction of the sound systems of the ambient language.

2.2.4. Development and discrimination

New-borns can distinguish between certain pairs of languages, at 2 months, they lose this ability in an interesting way. At 2 months, English and American babies cannot distinguish French from Russian or French from Japanese, they can however, distinguish Dutch from Japanese.

The rhythm-based hypothesis would propose that some development has taken place and the English child has adjusted to the ambient language which is stress-timed. Since Dutch has a rhythm that is very close to English (vowel reduction, complex syllabic structure, same trochaic word stress) it probably fits the representation also used for English. So the English child can discriminate Dutch from Japanese because Dutch is treated like English. In contrast, French, Japanese and Russian do not fit the rhythmic pattern of English and are thus all lumped together as “foreign”. At five months, however, English babies distinguish Dutch and English – so we expect that form that time on they cannot distinguish Dutch and Japanese.

One puzzle remains, why should the English child have difficulties in discriminating Russian and French? The answer may lie in the idea that some languages are very close (Dutch and English) whereas Russian, which is also stress-timed, still has other phonological properties (less vowel reduction etc.) which makes it more ‘foreign’.

2.2.5. Syllables and vowels

The rhythm-based hypothesis holds that infants perceive speech in terms of syllable-like units, more precisely that they pay attention to the nuclei of syllables, the vowels. So the vowel is the universal unit that infants use to organize and represent speech.

A series of experiments have provided evidence for the importance of the vowel and the syllable for infants. It was shown that babies detect the change from bi-syllabic to tri-syllabic words. Moreover, babies could detect a vowel change in a new syllable (habituation: 4 syllables with the different vowels but the same onset consonant, test: addition of a new syllable with a new vowel), they could not detect a new syllable if the change concerned a consonant (habituation: 4 syllables with same vowels but different onset consonant, test: new syllable with a different consonant).

Table 3

Summary of Bertoncini et al.'s (1988) experiments

Habituation phase	Experimental phase	Results
Same vowel [bi], [si], [li], [mi]	New consonant [bi], [si], [li], [mi], [di]	No detection of the new syllable
Same consonant [bo], [ba], [bi], [bə]	New vowel [bo], [ba], [bi], [bə], [bu]	Detection of the new syllable

Mehler (1981), Bertoncini et al. (1995), and Mehler et al. (1996) (see also Dehaene-Lambertz 1998 concerning syllable discrimination by premature babies).

From Guasti 2003, p. 40

Especially the last experiment shows that the vowel is a very important cue and that babies 'log-into' language via the rhythmic patterns they detect for vowel sequences.

2.2.6. Intermediate summary

- infants display a specialized ability to deal with speech input
- at 4 days they can discriminate their native language from other languages
- at 4 days they can discriminate two foreign languages (under certain conditions)
- such discrimination is based on rhythmic properties of languages
- initially infants pay attention to vowels or syllables and represent speech in terms of these units
- this representation is sufficient to classify languages into rhythmic groups and serves as a basis for a more fine grained representation which can capture other phonological properties of the native language

2.3. Learning the Phonemes of the Ambient Language

The rhythmic properties of a language are not the only acoustic properties where languages vary. We have seen that on the level of the organization of the sound system, languages can differ considerably on which sound segments or even which features distinguish meaning. Remember that nasality (and rounding) was a distinctive feature for French vowels, not for English vowels, that the aspiration of plosives is a distinctive feature in Thai, not in English, and that the 'liquids' /l/ and /r/ are not different phonemes in Japanese. It is well known that adult speakers of a language are very efficient in perceiving the phoneme contrasts of their native language but often hopeless in dealing with phonemic contrasts of foreign languages (which are not also present in their own language).

This efficient discrimination is partly due to the fact that phonemic perception of consonants in adults is **categorical**. This means that adults perceive a clear difference between [pa] and [ba], i.e. they distinguish two phonemes different only in voicing. They have a hard time distinguishing two acoustically different instances of [ba], however. Subtle acoustic differences are not perceived within the range of a phoneme, the same difference is perceived as distinguishing two phonemes when it occurs at the boundary.

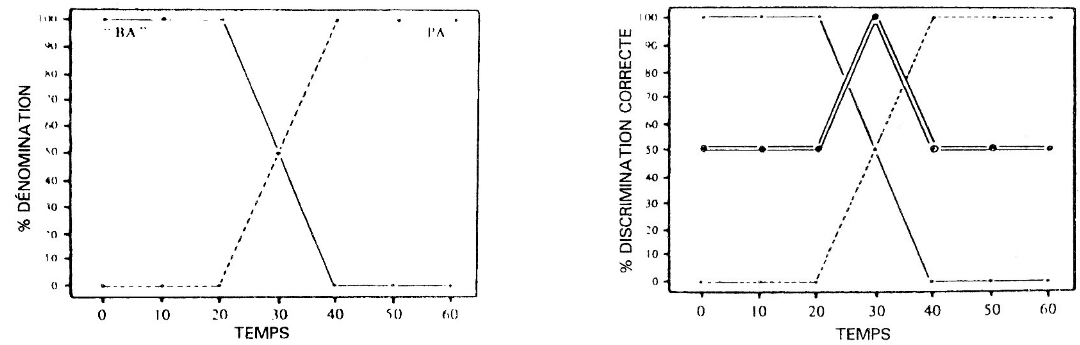


Figure 3

Sounds can vary physically in a continuous manner. What we hear varies in an abrupt fashion.

When a physical continuum is categorized, the ability for discriminating two sounds is maximal near a boundary.

From Mehler 1995, p. 231

On this background several possibilities exist about how children acquire the phonemic contrasts of their ambient language. One could assume that the newborn's mind is a blank slate and that infants must acquire the discriminations valid in their language. One could also assume that infants come endowed with all the possible contrasts and they then selects the ones operative in their language and forget the rest. A crucial question is therefore what infants distinguish at birth and whether they perceive speech sounds categorically or as a sound continuum and have to determine the acoustic range of a phoneme.

2.3.1. Categorical perception of distinctive features or phonemes

In 1971 Eimas and his group showed with the HAS technique that 1-month-old infants distinguish /ba/ and /pa/ categorically like adults. This means that acoustic differences that adults map into distinctive linguistic categories are perceived as different by babies and acoustic differences that are not linguistically relevant for adults are not perceived as distinct by babies.

It was objected that the voicing contrast on plosives may be the most salient contrast and that the perception of other contrasts might be more difficult. Subsequent experiments therefore showed that (2-months-old) infants also distinguish place of articulation (/ba/ vs./ga/, or /bɑ/ and /dɑ/ Morse 1972, Eimas 1974, or /nɑ/ and /ma/ Eimas and Miller 1980). Later it was shown that this sort of discrimination is present at birth (Bertoncini et al 1987) or that it can be perceived not only initially but also in word-final or word-medial position (Jusczyk and Thompson 1978). Manner of articulation such as the oral/nasal contrast in /ba/ and /ma/ was also distinguished early.

Eimas also investigated the perception of /la / and /ra/ as these sounds are not distinguished in production till quite late and do not constitute a phonemic contrast in some languages. It was found that 2-to-3-months old American babies reliably distinguished these liquids.

Early results on some other features are controversial, and especially fricatives seem to be problematic. Later studies showed, however, that even young infants have some capacity to distinguish place of articulation or voicing in fricatives (/fa/ vs. /θa/ and /s/ vs. /z/), even though this ability may not be quite as robust as for other types of obstruents.

It might be supposed that this ability of infants derives from experience with their native language. If this is the case, infants, like adults, should not be able to distinguish contrasts that are not instantiated in their environment, i.e. their native language. As it turns out, they do distinguish such contrasts.

Werker and Tees (1984) used a head-turning technique and tested English babies on non-native contrasts like the distinction of a retroflex (apico-postalveolar) and a dental place of articulation /ṭa/ and /ta/ or between breathy voiced and voiceless aspirated dental stops /d^ha/ and /t^ha/. They were also tested on a phonemic contrast of a Salish, a (Indian) language spoken in British Columbia, namely the contrast of a glottalized velar and uvular voiceless stops /k̓i/ and /q̓i/. The English speaking children distinguished these contrasts. So experience cannot be responsible for the ability to distinguish phonemes as infants are not exposed to non-native contrasts. At the same time, it is obvious that adults have lost this astonishing ability.

2.3.2. Developmental Changes in Phoneme Perception

The most important result of Werker and Tees' experiment was that babies lose the ability to distinguish non-native contrasts within their first year of life. Whereas English children can discriminate the Hindi or Salish contrasts at 6 to 8 months, they have lost this ability with 10 to 12 months. Hindi and Salish children keep the ability, of course. A similar experiment was run with Japanese children, and it could be shown that Japanese 6-to-8-months olds distinguish /la/ from /ra/, but no longer do so at the age of 10-12 months.

In order to control for the possibility that the auditory apparatus degenerates if the contrast is not reinforced so that the ear is unable to pick-up these distinctions later in life (12 months), another experiment was run. The same acoustic differences were presented to English babies not in a series of speech sounds but in a series of unrelated noises. It turned out that babies were still sensitive to these distinctions if they had pure acoustic value. They did not discriminate them when presented as part of the sound system of a language, however.

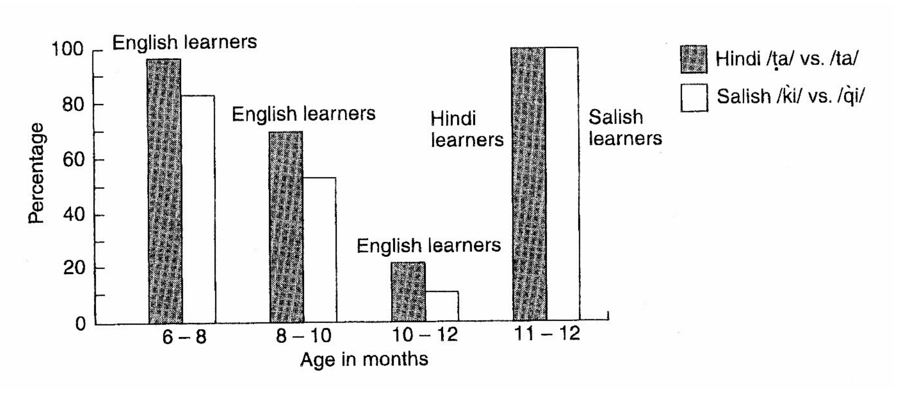


Figure 4
Proportion of American English learners from three age groups (6-8, 8-10, 10-12 months) and of Hindi and Salish learners (11-12 months) able to discriminate Hindi and Salish consonantal contrasts.

From Guasti 2003, p. 43

These results have shown that children start out with the ability to discriminate between native and non-native contrasts. At 12 months, however, they become like adults and can handle only native contrasts. So infants are not born with a blank slate which needs to be filled in but with a predisposition to recognize all possible phonemic contrasts. With experience, only the sensitivity to native contrasts is maintained. So the acquisition of the phoneme system of the ambient language proceeds by selection from the universal repertoire of sounds.

As this change does not reflect a change in the auditory system, it has been proposed that a functional reorganization of the sound space takes place at the crucial time: only those contrasts are maintained which distinguish meaning, i.e. have a function in the ambient language. This reorganization thus helps children in their task of learning words. English children will keep the contrast that distinguishes *lag* from *rag*, but will discard contrasts that do not have phonemic value because they are irrelevant for building a lexicon. Thus this functional reorganization is part of the program that progressively enables children to learn words. This decline in sensitivity to certain features, which at first glance appears to be a loss, is a gain in that it restricts the search space and the possible hypotheses. It thus seems to be a prerequisite for new achievements like learning words.

This early restriction to the contrasts of a native language also explains the findings about second language acquisition we have already discussed in the context of the critical period discussion. We saw that the later a language is learned the more a foreign accent is discernable and the less likely it is that phonemic contrasts of the second language which are not instantiated in the native language can be perceived (Pallier et al about Spanish and Catalan). Up to a certain age, a return to the initial possibility of perceiving foreign contrasts seems possible. The age limit is very low, however, and can be fixed at around 3 or 4 years.

2.3.3. Categorical Perception and the Language Faculty

It has been argued that categorical perception of acoustic signals is a language specific property (Eimas and Miller 1991). Other researchers have shown however, that other sounds besides linguistic stimuli can be perceived categorically (Jusczyk et al. 1980 and Jusczyk 1997), so that categorical perception seems to reflect a more general acoustic ability. It is thus possible that "language can take advantage of the auditory perception system by placing phoneme boundaries at auditory sensitivity peaks", Gerken 1994, 786. In this view, language has optimally exploited human perceptual capacities.

Another fact which has to mentioned in this context is that even animals have categorical perception. Chinchillas, macaques and Tamarin monkeys perceive speech sounds categorically and Tamarin monkeys can distinguish some pairs of languages (Dutch and Japanese). This finding suggests that "some aspect of human speech perception may have built upon preexisting sensitivities of the primate auditory system" Ramus et al 2000, 351). However, it is only in humans that they are used for language acquisition and to map linguistic structures.

2.3.4. Intermediate Summary

at birth infants are able to distinguish a wide variety of sounds

- this enables them to acquire any language they are exposed to
- this sensitivity changes during the first year of life
- at 12 months infants are like adults and can only distinguish the contrasts of their native language
- this loss of sensitivity is necessary for the building of a lexicon

2.4. Speech Production

Speech production abilities do not appear before the age of 6 months. The first sounds are cries, vegetative sounds, isolated vowel sounds and occasional consonants. With the onset of

babblin*g* at around 6 months, an important milestone in linguistic development is reached. Babbling can be considered a precursor of language in that it consists of syllable sequences like *bababa, dadada*, *dabada* etc.

It has been argued that babbling cannot occur before a certain maturation of the speech organs has taken place, which explains why speech production seems to be delayed with respect to perception. However, the onset of babbling cannot only be determined by the anatomical schedule of a change in organs. This follows if we consider that hearing infants start their **vocal babbling** when deaf infants start their **manual babbling.** Since manual babbling does not depend in any way on the development of the oral apparatus, it has been argued that babbling is the outcome of a maturation of the neural substrate supporting language.

The close similarity of vocal and manual babbling also implies that humans are born with a special sensitivity not to sounds per se but to particular units, structures and regularities found in natural languages independent from the modality of expression.

2.4.1. The vocal apparatus

Children's oral cavities resemble more to that of chimps than that of adults till about 4 months of age. Newborns have a higher larynx, a smaller throat, a shorter vocal tract and a different tongue shape. These properties limit infants speech production. At around 4 months, important changes take place, the larynx descends and also the rib cage changes enabling infants to produce longer periods of sound emission. These changes have to be accomplished before vocal babbling can start.

2.4.2. Vocal babbling

Babbling is a form of linguistic production and not as Jakobson (1968) claimed a prelinguistic phenomenon unrelated to the acquisition of language. Babbling is characterized by three properties:

- a syllabic organization
- the use of a subset of the possible sounds found in human languages
- the absence of an associated meaning

Canonical babbling consists of a sequence of repetitions of the same CV syllable: *bababa, dadada*, *mama*. It is an instance of producing the most typical syllable of adult languages. **Variegated babbling** combines different syllables and has a more varied prosody *babada, dabada, dabo*. Variegated babbling resembles word production – without meaning, however. Both types of babbling can occur at the same time and thus do not constitute different phases of development.

At the beginning of babbling, the phonetic productions show universal features and is not limited to the syllables or sounds of the native language. Very fast, however, the native language starts to influence babies' babbling. At 8-to-10 months, the quality of vowels produced by French and Arab babies is different (Boysson-Bardies 1998) and reflect the vowel quality of French or Arab respectively. At the same time, consonants which are very frequent in the words of a language tend to be equally frequent in the babbling of a baby exposed to that language. Labials are more frequent in French than in English and occurred more often in the babbling of French children than in the babbling production of English children. Dentals are more frequent in Japanese than in French and Japanese infants produce more dentals than French infants. So the statistical tendencies of the target language are reflected in babies' babbling.

The same is true for elementary syllable structures in disyllabic production. The CVCV syllable sequence is very common in French, English and Swedish, whereas a disyllabic word in Yoruba tends to have a VCV structure. Infants babbling “in Yoruba” produce the VCV structure very often whereas French, Swedish or English babies babble in the CVCV pattern (see above).

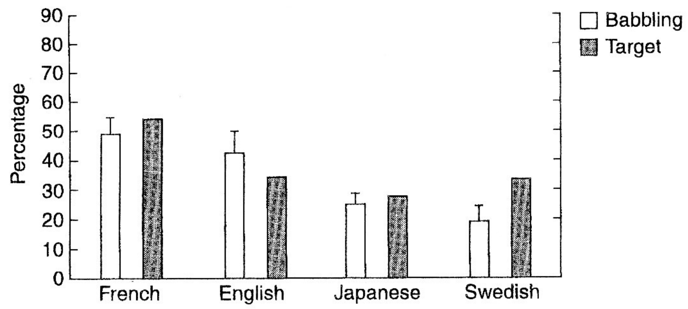


Figure 5
Distribution of labials in babbling and target words of the adult reference sample in four languages. (Adapted from Boysson- Bardies and Vihman 1991. Used with permission from the Linguistic Society of America.)

So it can be concluded that by 8-to-10 months, infants production is influenced by their experience. Remember that at this point infants ability to distinguish foreign contrasts or to discriminate between languages has already declined. Language specificity is therefore evident at this age both in production and in perception and infants are converging towards the sound system of their native language in both areas.

2.4.3. Manual Babbling

At the same time when hearing children start to babble vocally, deaf children exposed to sign language start to babble manually. This babbling is different from gestures and from rhythmic manual motor activity. It shows features similar to vocal babbling in that it has a syllabic organization. The signs used in babbling are a subset of the signs used in sign languages and they are employed without meaning. There are two types, canonical and variegated and from about 10 months, the repertoire of signs used reflects properties of the ambient sign language.

These facts are suggestive for the human language capacity as they indicate that it is not the development of the vocal tract which drives the first productions of language. They rather indicate that these first speech productions are controlled by a unitary language capacity. This language capacity would be an amodal capacity sensitive to the kinds of patterns “that correspond to the temporal and hierarchical grouping and rhythmical characteristics in natural language phonology”, Petitto and Marentette 1991, 1495.

The findings on manual babbling can also be interpreted in the following way. Speech is the natural mode of expression of the language capacity, but if this mode of expression is impaired or excluded, the language capacity can reorganize itself and find other means of expression. The use of sign languages seem to be a natural way out in situations where subjects do not have access to speech. It was shown that deaf Chinese and American children who were not exposed to a conventional sign language created a gesture system spontaneously. Gestures do not necessarily have the properties of language, but these systems had: order of elements within sentences, case marking on arguments. Moreover, both systems were very similar. This would not have been possible if the human language capacity did not shape the invention of these gesture systems.

2.4.4. Babbling as the forerunner of word production

At the age of 10-12 months, a time when they are still babbling, infants produce their first words. For a period of about 4 months, babbling and word production overlap. There is a continuity in babbling and word production in that there is a great similarity in the frequency of the sounds produced in babbling and in the first words. There were differences, of course, as word production draws on a greater combinatorial variability and the planning of coarticulatory sequences.

2.5. Summary

- from birth infants show a great sensitivity to the phonological properties of languages
- they distinguish languages from one another by their rhythmic properties
- new borns distinguish non-native and native phonemic contrasts, which is necessary for a child to acquire any given language
- at 6 months, infants start to babble
- at 8 to 10 months, infants loose their ability to distinguish non-native contrasts and start to babble "in their native language"
- infants are endowed with a rich innate ability and acquire their native contrasts by selection, they are thus working backward
- in the first year of life infants become attuned to global properties (prosodic structure) and the phonemic system of the language they are exposed to (learning by forgetting)
- this loss of universality is necessary for the next step, the building of a lexicon, in that it narrows down the hypothesis space

2.6. Developmental Steps

At birth infants

- discriminate their native language from a foreign language,
- discriminate between two foreign languages,
- can count syllables and thus vowels in a word,
- perceive an accent.

At 1 month infants discriminate between consonants.
At 6-8 months infants start to babble.
At 8-10 months

- infants vowel quality is influenced by the ambient language,
- infants sensitivity to foreign consonantal contrasts starts to decline.

At 10-12 months infants

- cannot discriminate consonant contrasts belonging to a foreign language,
- use a repertoire of consonants during babbling that is influenced by their native language,
- produce their first words.

Chapter 3: The Acquisition of the Lexicon

Children learn vocabulary quite fast, at around 10 or 12 months they understand some words, at
1.6 or at 2.0 at the latest they know and produce about 50 words and then there is a burst in lexical development called the vocabulary spurt. Vocabulary grows exponentially for a time, and from 2.0 to 6.0 children learn 5 to 9 new words a day. The second birthday constitutes another turning point as we suddenly find more verbs in the vocabulary and the first word combinations occur.

Learning words involves two tasks:

- segmenting the speech stream into word-sized units (this gives the child a phonological lexicon of word forms)
- associating meanings with these word forms.

In the following we will concentrate on how children build their lexicon using phonological information to break up the speech stream into words. This process is called phonological bootstrapping (tying your boots – getting ready for something with the help of phonology, the term 'bootstrapping' is used if some abstract property is acquired by some concrete help in the input, here words are acquired by using phonological information as straps). We will also look at the problem of how the meaning of nouns and verbs are acquired and how, given the lexicon, children bootstrap into syntax.

We will see how prosody and phonotactic constraints can help the child to build one side of the lexicon, the sound side, and that it is not easy to pair phonological words with meaning as multiple information can be drawn from one given situation. This problem is especially acute for verbs, for which it has been suggested that structural cues are exploited for the assignment of meaning. This raises the question, however, how children come by a structural representation and thus how they acquire syntax.

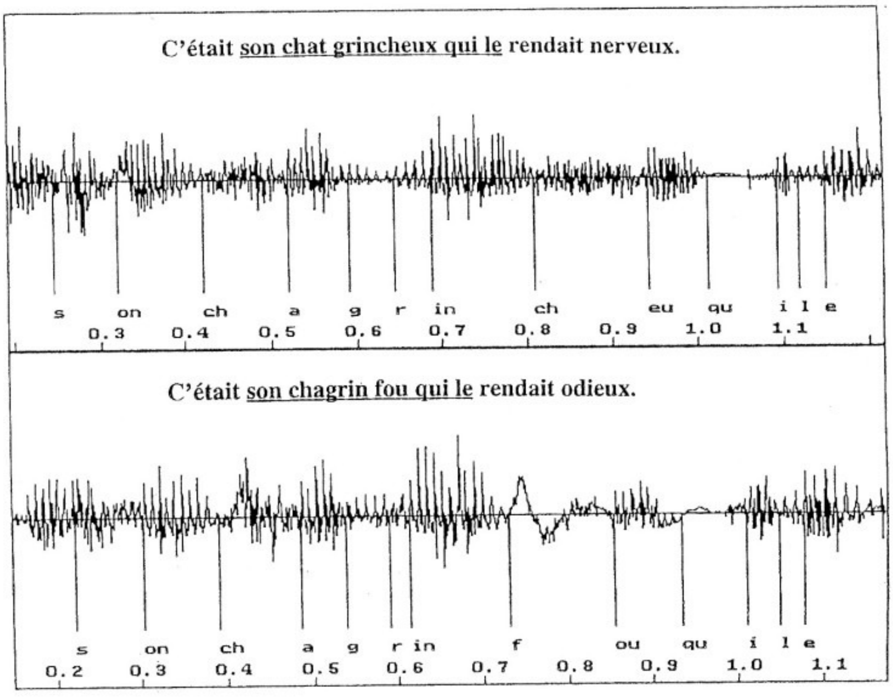


Figure 1
Spectogram of the underlined parts of the French sentences *C´était son chat grincheux qui le rendait* (top) and *C´était son chagrin fou qui le rendait odieux* (bottom). The vertical lines mark the beginning of each phoneme. (Reprinted from Christophe and Dupoux 1996. Used with permission from Mouton de Gruyter.)

From Guasti 2003, p. 57

3.1. The Problem of Identifying Words

In speech, words are very hard to identify – an experience everyone has who has ever listened to a totally unkown language spoken.

Consider the two sentences given in (1)

(1a) C'etait son chat grincheux qui le rendait nerveux
(1b) C'etait son chagrin fou qui le rendait odieux.

(1a) and (1b) share the same sequence of phonemes up to the syllable *grin*, in (1a) we would place a word boundary after the syllable /ʃa/, in (1b) we would not. An acoustic wave analysis of these sentences shows that in neither case there is a break.

This desperate situation is what children face. They are rarely taught isolated words but are exposed to highly ambiguous input as the sentences in (1) show. (experiment: 3 mothers presented words in isolation, 9 did not). Even if infants were taught isolated words, this does not help much as the same phoneme sequence may occur without the morphemic value assigned in the word:
if a child knows the word *can*, there could be erroneous segmentation of '*cancer, uncanny*' and others. Moreover, often more than one segmentation is possible*: ice cream, I scream.* So the problem is really tough one. Adults can do this segmentation quite efficiently depending on their lexicon and one the syntactic, semantic and pragmatic information present in the sentence and the situation. Children cannot do the same: they do not have a lexicon. So the problem is the following.

- Speech is continuous
- Words are not taught in isolation
- Infants are not born with a lexicon.

It follows that infants cannot break into the speech stream by using their knowledge of words, they have to somehow be able to segment the speech stream into discrete chunks, that is they have to discover word boundaries. Note that no computer has yet succeeded in segmenting continuous speech.

3.1.1. Phonological bootstrapping

The first idea is that children initially break up the speech stream into larger prosodic units such as the sentence or syntactic phrases. We know that in English, a fall on the last stressed syllable marks the tonic syllable of an utterance and thus signals the end of the sentence. We also know that fall-rise patterns in pitch signal syntactic boundaries. We know that stress falls on the first syllable in a bisyllabic compound in English, see (2a,b).

(2a) Bill gave her cat FOOD

(2b) Bill gave her / CAT food.

All these prosodic cues can be used by the child to segment the speech stream. As we already know that children are highly sensitive to prosodic cues, the hypothesis of prosodic or phonological bootstrapping is plausible.

A model of such bootstrapping is shown in the diagram below.

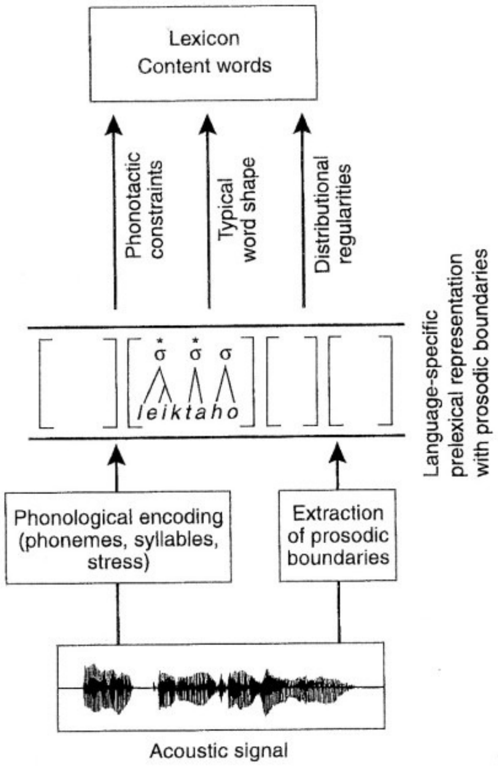


Figure 2

A possible model of phonological bootstrapping of lexical acquisition that rests on the prelexical prosodic segmentation hypothesis (see Christophe and Dupoux 1996; Christophe et al. 1997)

From Guasti 2003, p. 61

Interpretation:
Infants hear a sequence of sounds. From this they build a pre-lexical representation in terms of phonemes and syllables which means that they encode the acoustic input in language specific units. They also mark this representation with prosodic information as stress and syllable length. Using these cues they segment the speech stream into smaller prosodic units each corresponding roughly to a constituent and containing two or three words. Let's assume there is something like a syllabic representation as given in the figure. Then several phonological processes can help to further segment the signal:

- distributional regularities
- typical word order shapes
- phonotactic constraints.

Distributional regularities means statistical information about the distribution of sounds. In any given language the probability is higher for two sounds to follow each other if they occur in a word than when they never occur in one word but belong to two distinct words (Harris 1954).

If you check in the lexicon which syllables can follow the syllables *ele-*, you find -*gant*, -*phant*, -*vator* and a few others. So the probability for -*phant* to occur after *ele* is perhaps 1/10 and not much lower. If you look at the syllable -*phant* in *elephant*, an almost infinite number of possible continuations suggests itself. So the probability that *is* follows this syllable is maybe 1/100 or even lower. *The elephant went, is, was, goes, in the bush, next to*

John, *that I saw etc.* Computers can find about 40% of the relevant word boundaries exploring such transitional probabilities in continuous speech. So it is possible that children can also exploit this possibility – though it is hardly enough.

Regularities in the rhythmic properties of words can give rise to **typical word shapes**. In English most content words begin with a strong syllable – and we have therefore classified English as intrinsically trochaic. Placing a word boundary before a strong syllable may therefore be an effective strategy for English children – which does not always work, of course.

Phonotactic constraints determine which phonemes can occur together in a syllable or a word in a given language. Remember the strong constraints on phoneme combinations as the onsets of syllables which are therefore also valid for the onset of words. In English, /dstr/ does not occur word internally, so the sequence must be spread over two words and given the onset constraints, it is likely that /d/ belongs to the termination of a word and /str/ belongs to the onset of the new word. The sequence /kt/ is a possible combination inside words in English (*phonotactic*), but it is excluded word internally in Italian. So whenever infants hear an illegal cluster they will tend to place a word boundary within this cluster.

All these strategies are specific to a given language as they exploit language specific properties. So cannot be operative before the child has narrowed down the universal inventory. They cannot apply to the acoustic signal directly, they apply to phonemes and syllables. They thus require some language specific representation. Prosodic boundaries may be discovered directly from the speech signal and are thus less language specific and may be more basic and could be established earlier in development.

3.1.2. Plausibility of Phonological Bootstrapping

We have to show that it is possible to build word segmentation on such cues and that infants are indeed sensitive to such information in order to give some plausibility to the idea of phonological bootstrapping.

3.1.2.1. Prosodic boundaries

Phonetic studies have shown that clause boundaries are marked by three cues: pauses, syllable lengthening, changes in pitch.

That infants are sensitive to such cues was demonstrated with an experiment where a story was told with natural intonation patterns, where all three of these cues combine correctly. This story was contrasted with an artificially cut up story where the pauses were not at constituent or clause boundaries but at syntactically unpredictable places. The pauses thus did not coincide with the two other cues which were preserved. Infants decidedly did not like to listen to the broken up story, showing that they are sensitive to the fact that several factors need to coincide to give natural intonation.

Another experiment run with French children showed that 3-day-olds could detect a prosodic boundary between words relying on stress and syllable lengthening:

In *panorama typique*, *ma* is stressed and lengthened and *ti* is also lengthened. In *mathématicien*, there are no prosodic boundaries in *mati*. Children distinguished these two versions of *mati* three days after birth.

These experiments show that children extract a prelexical representation with prosodic boundaries from the speech stream giving plausibility to the hypothesis that the first step is breaking up continuous speech not into words but into larger prosodic units and that prosodic cues occurring at word boundaries are perceived very early.

3.1.2.2. *Pabiku* or distributional regularities

The question we ask here is whether children are sensitive to the transitional probabilities of one sound or syllable following another one. A famous experiment run in 1996 showed that the answer is yes.

Saffran, Aslin and Newport 1996 presented 8-months-old American babies with continuous speech consisting of 4 three-syllable nonsense words in alternating order for two minutes (habituation phase). In order to eliminate any prosodic cues and leave only the statistical probabilities, these words were produced by a speech synthesizer in an absolute monotone. What infants heard was something like: *pabikutibudogolatudaropi*.

There were two groups presented with different nonsense words during the habituation phase as shown in (3).

(3) Habituation:
Group A: pabiku tibudo golatu daropi golatu tibudo pabiku daropi...
Group B: tudora pigola bikuti budopa pigola tudaro bikuti budopa bikuti...

Both conditions contained the same sets of syllables in order to exclude that there might be preferences for certain syllables. Could babies detect that in condition A the probability for *bi* following *pa* and for *ku* following *bi* was higher (they are parts of the word *pabiku* and the probability of transition is 1.0) than for *ti* following *ku* (*ti* is the beginning of a new word and could follow *ku* but also *tu* or *pi*, the transitional probability is thus 0.33).

In the test phase babies were then presented with two words from the sequence and two 'part words' formed by the last syllable of one of the nonse words and the first two of another one of the nonse words, say *tudaro*). Note that no new syllables were introduced.

(4) Test phase for both groups:
pabiku pabiku pabiku.... tibudo tibudo tibudo... tudaro tudaro tudaro... pigola pigola pigola...

If infants calculate transitional probabilities, then for babies in condition A *pabiku* and *tibudo* are words whereas *tudaro* and *pigola* are part-words. For babies in condition B *pabiku* and *tibudo* are part-words and *tudaro* and *pigola* are words. Note that now they were presented not with just the speech stream but with repetitions of the words and the part-words. It turned out that babies in both conditions listened longer to what for them were part-words. As babies are more interested in new things, it can be concluded that they perceived these as new, i.e. they knew that these had not been words before. The conclusion is that 8-months-old babies can calculate transitional probabilities after two minutes of exposure to a (repetitive) sound stream.

3.1.2.3. Typical word shapes

The next question is whether babies are sensitive to rhythmic properties defining typical word shapes. It was found that 6 months old American babies preferred to listen to lists of bisyllabic English words over lists of bisyllabic Norwegian words. This combination of languages was chosen because English normally has the pitch rise on the first (trochaic) whereas Norwegian has it on the second syllable (iambic). This preference was preserved even in low-pass filtered speech which takes away any other phonetic cues and leaves only prosodic information. So 6 months old babies are capable of recognizing native words in terms of their prosodic structures.

It was shown that English adults do a rough speech segmentation by placing a word boundary before a strong syllable (Cutler et al 1986) and this was corroborated for English infants: By 9 months, English babies prefer to listen to word lists of bisyllabic words staring with a strong syllable (*candle, cable, husband, story*) than to lists with a strong second syllable (*guitar, decay*). They seem to have discovered that English is basically trochaic.

3.1.2.4. Phonetic and phonotactic features

Languages differ with respect to the phoneme inventory they exploit (English has /θ/ and Dutch has not) and with respect to the phoneme combinations allowed inside of words (English allows /tʃ/, Dutch does not).

6 months old babies could not distinguish Dutch and English word lists even when they contained several of the above differences. So at that age they are not sensitive to phonetic and phonotactic properties – we know that they have only just begun to lose their ability for universal discrimination. Remember that Dutch and English are both trochaic and have other similar prosodic properties on the utterance level.

The picture changes at 9 months of age. Now babies are well into the process of forgetting the contrasts not operative in their native language and they begin to rely on phonetic and phonotactic information. 9 months old English babies can distinguish Dutch and English word lists, but they cannot do so after low pass filtering. Remember low-pass filtering takes away phonemic characteristics but preserves prosodic information. Dutch and English are both trochaic, so it must have been phonotactic and phonemic information which enabled babies to distinguish.

Narrowing down the experiment to phonotactic constraints, English babies were presented with word lists containing phonemes current in both languages differing only in phonotactic properties. Left only with these phonotactic cues, babies could still distinguish Dutch and English word lists. We can conclude that at 9 months, babies are working with fine-grained properties of the sound system of their native language.

3.1.2.5. The discovery of regularities and UG

The puzzle which has to be solved now is how babies come to know such regularities. They do not have a lexicon to inform them that /kn/ does not occur word internally. The only possibility is that it is indeed statistical information which allows to extract such regularities (see the *pabiku* experiment). Such information must rely on the early availability of prosodic boundaries: when a cluster is licit it may sometimes be separated by a prosodic boundary and sometimes not, when a cluster is illicit it will always be so separated.

Another kind of help is provided by the fact that word initial clusters may sometimes occur at the beginning of an utterance and word final clusters may sometimes occur at the end giving information of possible clusters. English babies can also exploit the fact that prosodic boundaries are often found before strong syllables which allows them to make a conjecture about typical word shape.

The building of the phonological lexicon thus proceeds from a prelexical representation on which prosodic boundaries are superimposed. By using statistical information on transitional probabilities at prosodic boundaries they can extract distributional regularities, typical word shapes and valid phonotactic constraints. Based on these cues they proceed to extract the units which form words of the language.

As the most important procedure involved in this process is of a statistical nature, it may be asked what the role of UG is in all this. It looks more like a general purpose learning strategy than a predisposition for language treatment.

It is imminently clear that statistical mechanisms must be involved in many processes concerning language specific input. It does not follow, however, that even if word segmenting relies on a statistical learning skill, this skill is sufficient to acquire all other aspects of language. Remember that it is highly unlikely that any statistical analysis can inform the learner about the distribution of pronouns and anaphors as discussed in Chapter 1.

3.1.2.6. Intermediate summary

Infants draw on prosodic information to arrive at a preliminary speech segmentation. With the aid of statistical processes they extract distributional regularities, typical word shapes and phonotactic constraints. At the age of 8 to 9 months infants start to recognize words based on these cues. Some of these words may be already connected to meaning but most of them are not. So the building of the lexicon seems to proceed in two steps: identify the words and store their phonological shape, then extract their meaning. We will now turn to the second phase and the problem of how to assign meaning.

3.2. The Problem of Acquiring Meaning

A very basic question is how toddlers know at all that words have reference and - if we grant such knowledge – how they arrive at assigning a particular reference to a particular word. The assumption here is that infants have a disposition to refer to things and to recognize this intention in other humans. So now we are left with the question of how the child can figure out that a particular word refers to the object s/he is holding or – to make it more difficult – to the object the mother is holding.

A very simple proposal is that there is an assumption of temporal contiguity, so that a word which is uttered in a situation is associated with an object present in the situation at the time of utterance. Quite clearly the assumption is that a word is associated with what is perceived when the word is spoken, which is essentially a **word-world mapping**.

There are multiple problems with this suggestion. First, in a given situation several objects may be present. If a cat and an elephant are present, the word *cat* may refer to either animal or to the tail of the cat or the trunk of the elephant. Another obvious problem are abstract nouns whose meaning cannot be perceived. This problem becomes acute when we consider verbs as usually the utterance of the verb and the event do not co-occur.

(5a) You broke the glass.
(5b) Bring me the doll.

Moreover, one situation can be described in different ways as in (6).

(6) John gave Mary a book/ Mary received a book from John

Or look at the scene shown in figure 3

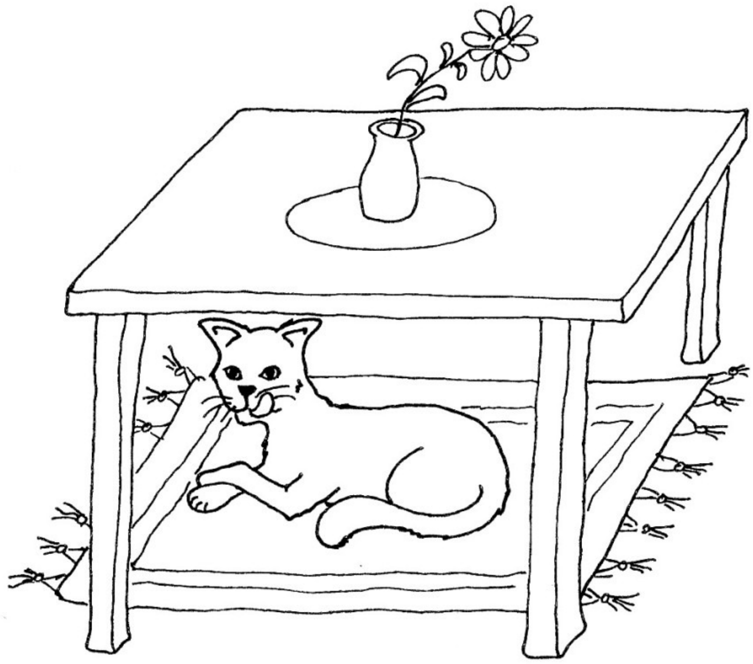


Figure 3
From Guasti 2003, p. 76

Focusing on different aspects of this scene you could utter any of the sentences in (7). So the word-world mapping is clearly flawed by a **problem of induction**.

(7a) The cat is on the mat
(7b) The mat is under the cat.
(7c) The cat is under the table.
(7d) The vase is on the table.

3.2.1. Biases on Word Meaning

In order to solve this problem, a number of biases have been proposed. If toddlers have a predisposition to establish **joint attention** with the adult they are interacting with, they could be more sure that the adult and they themselves are talking about the same thing and focusing on the same object present in the situation. Indeed it has been shown that toddlers can use non-verbal cues of joint attention as the direction of the gaze of their partner in order to focus on salient aspects of the situation. This can at best tell the child what the adult is referring to and at worst, it keeps the child from making a wrong conjecture. Such an ability is not enough, however, and there are certain biases about word meaning: the **whole object**, the **mutual exclusivity**, and the **taxonomic bias**.

Following these biases the child assumes that a novel label is likely to refer to the whole object and not to its parts, substance or properties. In the above scene, the child would therefore assume that *cat* refers to the whole cat, not to its tail and not to its furriness. Having established this, children are led by the taxonomic bias to extend this label to objects of the same **kind**, not to objects which are related via a shared accidental property (spatial, temporal or other). So the child would extend the label *cat* to another (maybe a black) cat, not to the mat which is also under the table and thus in the same spatial relationship to the table as the cat. The last bias, mutual exclusivity, predisposes the child to assume that there are not two labels for the same thing. So if in the above scene with the cat, they hear *'look, she's flicking her tail'* they will assume that *tail* cannot also refer to the cat, for which they already have a word. In this situation they will therefore infer that the new label may refer to a part of the cat or to a property.

These biases only give certain tendencies and children must be able to override them. Moreover, biases may help but they do not suffice to learn the meaning of abstract nouns, or verbs, prepositions and other functional words. Even within the class of concrete nouns the scope of biases is very limited. They cannot help the child determine whether a noun is mass or count – especially as these categorizations are language specific and not always evident from the object itself (*hair*, *capello/capelli*). Learning these properties of nouns requires inspection of the syntactic context and indeed it has been shown that from the age of 2 years, children use such information to make count/mass distinctions.

3.2.2. Intermediate summary

Word meaning can be assigned to nouns by a word-world mapping following certain cues and biases. An important cue is joint attention, which enables the child to single out the salient object. The whole object bias, the mutual exclusivity bias and the taxonomic bias then guide the child in the assignment of meaning. These biases are not sufficient for mapping meanings of a more abstract kind (mass/count, verbs, abstract nouns). For these cases syntactic information is necessary.

3.3. The Acquisition of Verbs

It has often been observed that children learn verbs later than nouns. This is probably due to the fact that the acquisition of at least some nouns can rely on a word-world mapping and that the acquisition of verbs requires another procedure. It has been observed that at a time when there are 50 to 200 words in the vocabulary (around 2.0), children start producing the first combinations and that when they produce 400 words with many new verbs among this number, there is a correlation to the syntactic complexity of their utterances. So the conjecture can be made that there is a connection between vocabulary growth and syntactic productions, which means that new ways to learn words may have opened to the child – the observation of the syntactic environment.

3.3.1. Syntactic Cueing of Verb Meaning

As early as 1975 Brown suggested that children can use syntactic and morphological cues in order to distinguish between verbs and nouns. Children were presented with sentences like *show me a sib* or *show me sibbing*. In the first case a nonsense word was associated with an article, i.e. with typical noun syntax. In the second case there was a verbal inflectional morpheme attached to the nonse word. Children pointed to objects when presented with '*a sib'* and to actions when presented with '*sibbing*'. Pursuing this idea Gleitman et al. xxx propose that the syntactic context in which a verb occurs gives hints about its meaning.

The underlying assumption is that there is a close correlation between syntax and semantics and that children expect this correlation to hold. The crucial idea is to relate the argument structure of a verb to the canonical thematic roles these arguments assume in the event described by the verb.

(8) John broke the glass.

Here the child encounters two arguments in a transitive frame. As the most common order of arguments is agent/theme in such frames, the child will tend to interpret *John* as the agent and *glass* as the theme. The child can also infer that the verb *break* has a causative meaning as the agent is usually causing the effect the action has on the theme. If the child is presented with an intransitive verb like *laugh*, a cause-effect relation cannot be meant: the second argument, the one which could be effected, is lacking and the child will not assign a causative meaning to this verb.

When we discussed the thematic criterion, we also mentioned that in this way, syntactic structures are projected from the lexical properties (not always reliable). So observing the syntax should allow guesses on certain aspects of meaning.

(9a) John gorped that Mary came
(9b) Bill sibbed
(9c) John stog from Milan to Naples.

Gorp cannot be like *laugh* but must be more akin to *say, think* or *hop*e because it takes a clausal complement. *sib* is likely to be somewhat like *laugh*, and *stog* is obviously a verb of motion along a path. The exact meaning cannot be determined by this procedure but certain possibilities can be firmly excluded. Also the syntactic context makes it possible to exploit the extralinguistic context in a more efficient way as it delimits the hypothesis space.

It could be established that children are indeed guided by such syntactic cues. Exposed to a sentence like *the duck gorped the bunny* they would look longer at a picture which showed the duck doing something to the bunny than at a picture where the duck was doing something and the bunny was just looking on. The technique used here is the preferential looking paradigm where children are presented with the sentence and a picture simultaneously. The picture is either matching the sentence or not matching. Usually children look longer at the matching (correct) picture than the non-matching one.

Often, a verb is used in more than one frame and this narrows down the meaning even further. Children can use the information from several frames to come to a conclusion. Compare the causative alternation discussed in the semantics lectures. The agent argument can be omitted, but in this case the theme argument becomes the subject. The object cannot be omitted. These frames are shown in (10).

(10a) John broke the glass.
(10b) The glass broke.
(10c) *John broke.

Given these frames the verb must be causative. Contact verbs are also transitive and they also allow the omission of an argument. Here only the object, the theme can be omitted and the subject remains the same. In no case can the theme become the subject. These frames are given in (11).

(11a) John painted a picture.
(11b) John painted.
(11c) *The picture painted.

Presented with nonse verbs in these different frames, children could assign a causative meaning or a contact meaning respectively. The evidence provided with this sort of experiment is very striking as it indicates that children assign a structural representation very early. Note that the meaning of the verbs cannot be determined by their cooccurrence with certain nouns. What is necessary here is to realize that a former object has become the subject in one case but not in the other. For this sort of decision, a structural representation is required.

So we know that children can use syntactic information when it is systematically presented to them. The question is whether they actually get this sort of information in their natural input. In this context, studies on the acquisition of vocabulary by blind children are very instructive. We have already seen that the rate of acquisition is similar to that of seeing children. Landau and Gleitman 1985 noticed moreover that blind children assign a semantic representation to verbs of vision which is very similar to that of seeing children. Blind children know that *look* is active (involves the intention to see something) whereas *see* is not. Such verbs, when applied to themselves, are given a haptic interpretation – an interpretation in terms of touching and feeling. So when asked to *look* at a chair, they will touch it and explore it by touch (performing and intentional action). If they are asked to touch it, they merely tap on it. The conclusion was that syntactic frames must greatly narrow down the meaning and it was found that indeed, *look* and *see* were used in completely different frames very often by mothers of blind children. Note that you can use only *look* but not *see* in commands. See (12) and (13) for such distributional differences.

(12a) Look at this table!
(12b) *see this table.! (so this command will never occur)
(13a) Do you see this table?
(13b) Are you looking at this table?

Subsequently it was shown that most mothers use verbs in multiple syntactic frames and that children use verbs more frequently if they have heard them used in different frames. We can therefore conclude that syntactic information is available to children and that it is used in narrowing down verb meaning.

3.3.2. Intermediate summary

The syntactic environments in which verbs are inserted, together with the extralinguistic context in which they are used, provide reliable clues about certain global properties of the verb's meaning.

3.4. How to break into Syntax

A rather obvious problem faces us now. We have argued that children have access to certain structural representations and exploit them to build their lexicon. But where do these structural representations come from – or how do children get into syntax? This is another bootstrapping problem.

Even if we assume in the generative tradition that UG will guide children in constraining the possible hypotheses about grammar and even provides such notions as verb, noun, adjective or the basic hierarchical structure of each phrase, the X-bar schema, the task remains gigantic. Children have to classify the words they have identified into the grammatical categories, and then they have to find rules which are specific to their language. So the above question can be narrowed down to asking how children can build structural representations if they do not know which words belong to which grammatical category.

Again, the first step seems to be some sort of phonological bootstrapping, breaking up the speech stream into rough constituents. By what we know about children's sensitivity to prosodic boundaries, it is rather plausible that children can assign a flat structure with large unanalyzed chunks to a simple sentence, something like (14).

(14) $[_{ZP}$ $[_{XP}$the dog$]$ $[_{YP}$chased the cat$]$ $]$

Then semantics may come to the aid of syntax in that children exploit “certain contingencies between perceptual categories and syntactic categories, mediated by semantic categories”, Pinker 1994, 385). This is called **semantic bootstrapping**. The idea is that semantic entities are realized in certain canonical ways. We observe that in the majority of cases, objects are expressed by nouns and actions are expressed by verbs. Pinker therefore argues that children have access to such basic notions as person, thing, action, agent, patient. These are elements needed in the underlying interpretation of the sentences children hear. They get mapped onto their syntactic counterparts by the basic assumption that the word for a thing belongs to the category noun, the word for an action belongs to the category verb, the word for a property of an object belongs to the category adjective and a word indicating a spatial relation belongs to the category preposition. As to the argument structure of verbs, Pinker assumes that the thematic roles of these arguments allows the child to infer the grammatical function. Starting from a sentence and a co-occurring event, children build a semantic representation of this event, which - among other things - encodes the arguments and the thematic roles of these arguments. By inspecting these thematic roles, they then infer the grammatical function: agents will be assigned the subject function and themes will be assigned the object function.

Given the grammatical categories by semantic bootstrapping and the X-bar schema by UG, the various phrases (NP, VP, AP, PP) can be projected in the canonical way. Exploiting the semantic relations between verbs and their arguments, structure can be built. An NP having the thematic role of theme or patient, will be the complement of the verb, and the NP with the subject role will be inserted higher up to become the subject. Once these syntactic notions are acquired, children can learn the lexical category of new words and the grammatical function of arguments which are not immediately obvious by using structure dependent distributional analyses as described in 3.3. or used in exercise 5.

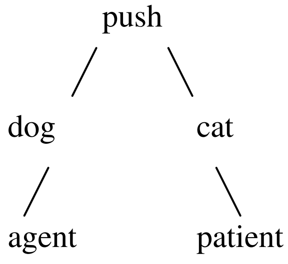
Alternatively, children start with a **partial sentential representation** around the nouns they know. This partial representation is given by prosodic analyses and resembles (14). This flat representation is the basis for a more hierarchical organization.

Suppose the child knows the nouns *cat* and *dog* by a simple word-world mapping but does not know the word *push*. For the *dog pushes the cat*, the child will assume that push is a verb – not because it is an action as in the semantic bootstrapping hypothesis – but because the child expects a predication and verbs express predicates. Based on the prosody and this expectation the child gets (15).

(15) [[...dog.]....[.pushes......cat]]

By inspecting the number of arguments, children conclude that the verb encodes a binary predicate or relation, i.e. has a transitive frame. Modulated by certain biases (which have psychological probability) the child will analyze the verb as causative and interpret the scene as an agent acting upon a theme. So children establish a first hierarchical structure encoding the verb as a binary predicate as in (16).

(16)



Note that this representation does not yet use the X-bar schema. From this representation, children will construct the notion subject: the first of the arguments and the agent argument. These two properties come together only in transitive frames, so these are considered crucial in the acquisition of syntax. By generalizing such structures, children will acquire more verbs, more subjects and more structures and eventually arrive at the X-bar schema.

3. 5. Summary

For breaking into the syntax which will then provide help for building the lexicon, the child is again faced with a bootstrapping problem. The child has to establish which word belongs to which grammatical category before building any kind of syntactic structure.

Phonological bootstrapping has been proposed to establish the boundaries of large constituents. Building on this, partial sentential representations have been proposed as the first syntactic structures or alternatively semantic bootstrapping has been suggested for a rough word-category and argument-function mapping.

These two latter proposals complement each other and it seems likely that they are both interacting. By combining the approaches we conclude that children start with a partial sentential representation given by phonological bootstrapping which is then fleshed out by structural assumptions about the basic argument-predicate structure of utterances as well as assumptions about a basic mapping between certain semantic and syntactic categories.

3.6. Developmental Steps Relevant for Building the Lexicon

At birth infants can perceive acoustic cues marking prosodic boundaries.

Between 6 and 8 months infants

- are sensitive to the prosodic coherence of clauses,
- prefer lists of bisyllabic words from their native language based on prosodic cues.

At 8 months infants

- can compute distributional regularities,
- can recognize words in continuous speech after familiarization with these words.

At 9 months infants

- can use phonotactic and phonetic constraints to discriminate between lists of words form their native and a foreign language,
- are sensitive to the prosodic coherence of major phrases,
- with English as their ambient language prefer to lists of bisyllabic words conforming to a trochaic pattern.

Between 10 and 12 months children start to pair words with meaning.

At 20-24 months children

- experience a vocabulary spurt,
- begin to produce multiword utterances,
- use syntactic information to infer word meaning.

Chapter 4: Early Syntax

4. 1. UG and the Principles and Parameters Model

In the last chapter we have seen that certain assumptions are made about what is innate and can guide children in the process of language acquisition. Earlier (Chapter 1) we had argued from the poverty of stimulus that certain grammatical structures must be innate and we had specified a model, the Principles and Parameters Model which is promising in that it gives a universal outline in the principles but allows variation in the parameters. Note that before this model was proposed, there was a basic dilemma about language acquisition formulated by Chomsky.

> It is, for the present, impossible to formulate an assumption about initial, innate structure rich enough to account for the fact that grammatical knowledge is attained on the basis of the evidence available to the learner. ... The real problem is that of developing a hypothesis about initial structure that is sufficiently rich to account for acquisition of language, yet not so rich as to be inconsistent with the known diversity of language." (Chomsky1965:58).

With the **Principles and Parameter (P&P)** model a perfect tool was created to solve this problem: It provides a system which is rich enough but not too rich to be rigid. Moreover, a more precise formulation of the possible differences of languages in the parameters made it easier to focus on the common core, the system of principles which is called Universal Grammar, UG. It was only a small step to assume that it is this common core of principles that is innate and that the acquisition process is a process of parameter setting through exposure to language particular input.

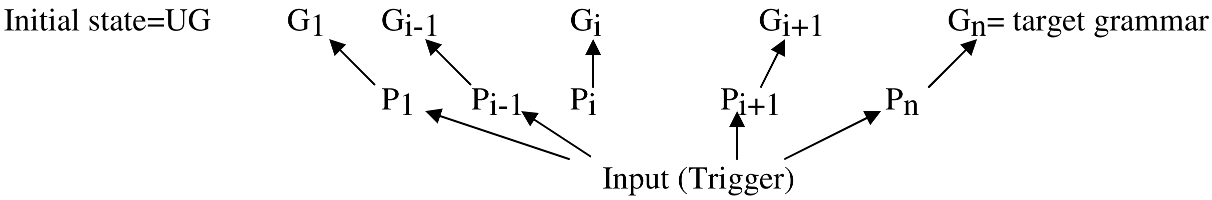
4.1.1. P&P and the learnability question

Admittedly, a P&P model can offer a theoretical solution to the above sketched dilemma in that it is a finite set of parameters which has to be adjusted to the values of the target language. This means that in the worst case the enumeration of all the logically possible parameter settings can provide the basis for a systematic search for the correct grammar.

This theoretical possibility does not survive the practicality test, however. For 30 parameters, and this is not a high number of parameters to characterize a natural language, the number of possible combinations is 2^{30}. Clark (1992) calculated that it would take about 34 years to arrive at the correct grammar - assuming a machine that could test every member of this set of possible grammars in one second. So the learner obviously does not match every possible parameter combination against the input. If this were the case, language acquisition would take much too long.

The next step is to view UG as a constraining device which delimits hypothesis formation and so offers deductive short-cuts. The learner's task is to set parameters correctly with the help of a certain input and the core principles of UG. The role of UG and input are now clear in as much as the learner, confronted with a suitable sequence of texts from the target language, will choose the parameter setting so that UG will map these values correctly to the target grammar.

In order to explain how parameters are set on the basis of input, the notion of a trigger was introduced together with the constraint that only one parameter should be set at a time. A trigger is any input string that provides unambiguous evidence for a certain parameter setting (see Lightfoot 1989 for a discussion). One of the first explicit models capturing these ideas is that of Hyams (1986).



4.2. Full Continuity and Early Parameter Setting

In accordance with the assumptions of an innate grammatical device, UG, the above model assumes that children's grammar will be in all cases UG conform. So children's grammatical development is continuous with respect to UG (no breaks, no point where UG is not available), which gives rise to the term **full continuity**.

From much recent research, it has emerged that parameters are set very early in the acquisition of syntax. This is true for the so-called head-complement parameter, the verb-raising parameters, the clitic parameters, and even the pro-drop parameter. We will concentrate on the following parameters: the head-complement parameter, verb raising to I, verb-raising to C and the clitic-parameter.

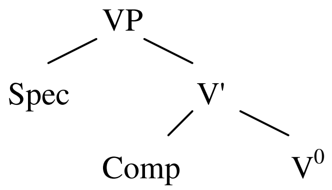
4.2.1. The Head-Complement Parameter

In the X-bar theory of phrase structure, every phrase has a specifier, a head and a complement which can be formally represented as in (1a, b).

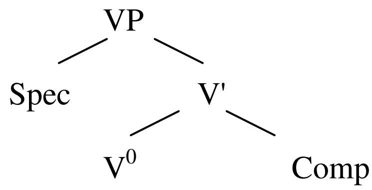
(1) a. XP -> {Spec, X'} b. X' -> {X^0, Comp}

This, the X-bar schema is considered to be a principle of UG. The order of constituents is parameterized, however. This can be seen in the canonical order of verbs and their complements, especially for verbs in the infinitive as these do not undergo any of the possible verb raising processes. Thus we find the structures (2a) for German and (2b) for English and French capturing the examples (3a) and (3b,c).

(2) a.



b.



(3) a. Jetzt möchte der Vater [das Baby *sehen*]
b. Maintenant le père veut [*voir* le bébé]
c. Now the father wants [*to see* the baby]

According to this parametric difference, German is characterized as Subject-Object-Verb or SOV, whereas English and French are Subject-Verb-Object or SVO. (See also the handout on Old English which we classified as SOV).

This regularity is mastered from the first two word combinations, i.e. from the beginning of syntax itself. In Radford (1997:22) we find: "children consistently position heads before their complements from their earliest multiword utterances." This is shown in the combinations given in (4) also quoted from Radford (1997).

(4) touch heads, cuddle book, want crayons, open door, want biscuit, bang bottom, see cats

German children do the opposite. They position objects behind verbs as a study of the child Simone by Penner, Schönenberger and Weissenborn (1994) has shown.

(5)	Simone	Obj. + Inf	545
	2.0-2.2.	*Inf + Obj.	9

(6) baby nich nuckel habe(n)
baby not pacifier have

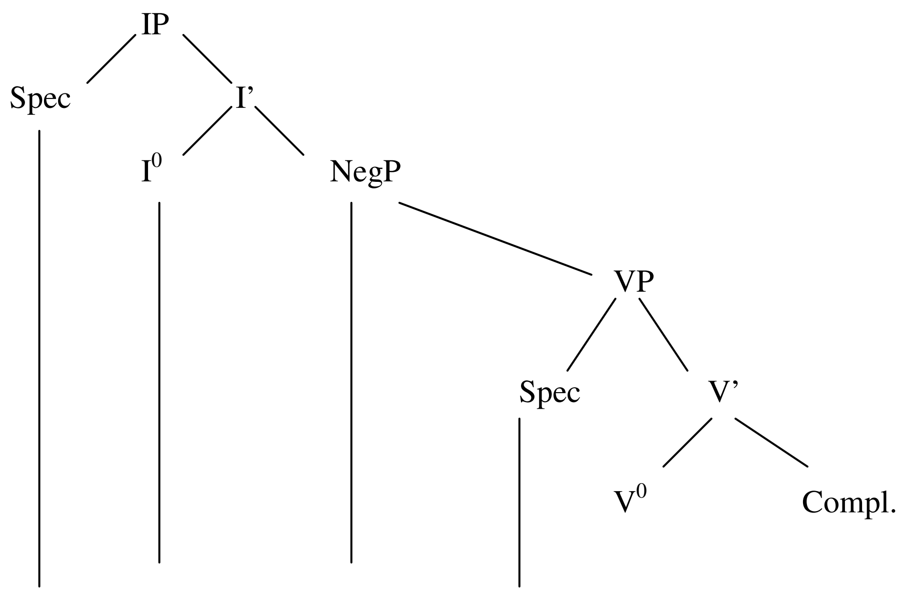
Example (6) gives a typical utterance of Simone's, and the data in (5) show that 98% of her objects and infinitives are correctly placed with respect to each other.

4.1.2. Verb-Raising to Inflection

Another parameter concerns the position of finite verbs. From the contrast in (7a) and (7b) Pollock (1989) deduced that the finite verb moves to Inflection in French whereas it stays in its base position in English. The tree in (8) and the examples below demonstrate that in French it is only finite verbs, not infinitives or participles which raise. The demonstration hinges on the fact that adverbs like *souvent* 'often' as well as the negation *pas* 'not' have a fixed place in the phrase structure tree, and that verbs show up on either side of these elements according to their being inflected or not. (See handout on Syntax where English main verbs and auxiliaries are contrasted with respect to this property).

(7) a. Jean voit souvent Marie
b. John often sees Mary

(8)



Jean	n' a	pas	t_i	mangé	la soupe
Jean	ne mange$_j$	pas	t_i	t_j	la soupe
*Jean	ne	pas	t_i	mange	la soupe

'John hasn't eaten/doesn't eat the soup'

Pour	ne	pas	t_i	manger	la soupe
*Pour	ne manger$_j$	pas	t_i	t_j	la soupe

'In order not to eat the soup'

Pierce (1989, 1992) demonstrated that French children as young as two years are sensitive to the finite/non finite contrast, see (9b), with respect to negation just as French adults are, see (9a). Table 1 shows that the distribution is consistent and that the verb raising parameter is set correctly.

(9)	a.	je (n') marche pas	vs.	je ne veux pas marcher	adult
		I ne walk not		I ne want not to walk	
		'I don't walk'		'I do not want to walk'	
	b.	veux pas lolo vs.		pas dormir	(Pierce 1992)
		want not water		not sleep (inf)	child

Table 1: Distribution of finite and non-finite verbs with respect to negation

French (Pierce 1992: three children ranging from 1;8 to 2;6)

	+finite	-finite
pas verb	11	77
verb pas	185	2

It can be demonstrated for English that children know that English is not a verb-raising language. English children know that lexical verbs do not leave the VP, whereas auxiliaries and modals do. Again, the position of the negation serves as the test case. We never find something like (9c) where the main verb would have moved as in French, we find (9d) and (9e) however.

(9c)	*John eats not	
(9d)	I can't see you	Eve 1.10
(9e)	I don't want soup	Eve 1.11

4.2.3. Verb-Rraising in Verb-Second Languages

Examples (10a-f) show a similar phenomenon of verb raising in German. Here, however, the finite verb always ends up in the second position of the sentence. This argues for the fact that the verb moves further up in the tree than to the Inflectional Phrase (IP), and the usual hypothesis is that the verb moves as far as the head of the complementizer phrase which provides the highest layer of structure in a phrase. The examples (11b,c,d) show that adverbs and other topicalized constituents can be in the first position of the sentence in German followed by the verb and then the subject. As the complementizer phrase (CP) is the place where topicalized constituents are placed, and the specifier of the IP is the canonical place for subjects, this hypothesis finds support in the data. Subordinate clauses also support the assumption as it turns out that in German subordinate clauses with an overt complementizer the finite verb does not raise to second position but remains sentence final. (See the handout on Old English where evidence was provided that OE was a V2-language).

(10) a. Hans kauft jetzt immer Blumen für Marie
John buys now always flowers for Mary
'John now always buys flowers for Mary'
b. Jetzt kauft Hans immer Blumen für Marie
now buys John always flowers for Mary
'Now John always buys flowers for Mary'
c. Blumen kauft Hans jetzt immer für Marie
flowers buys John now always for Mary
'John now always buys FLOWERS for Mary'
d. Für Marie kauft Hans jetzt immer Blumen
for Mary buys Hany now always flowers
'John now always buys flowers FOR MARY'

Tables 2 and 3 show that young German children already know that the finite verb must be moved to second position whereas infinitives must not. Table 2 shows the analysis of the speech of one child during one day. V2/not final means that these are clear cases of second position where another constituent followed the verb, not cases where the verb occurred in final position which also happened to be second.

Table 2: Distribution of finite and non-finite verbs with respect to V2
German (Poeppel and Wexler 1993: Andreas 2.1)

	+finite	-finite
V2/not final	197	6
Vfinal/not V2	11	37

Table 3 is an analysis of four German children of a young age following the same criteria in that only utterances longer than two words were considered. Both tables show that the Verb-Second (V2) property of German is respected from the beginning. Note also that some of the finite verbs can be found in final position which shows that children have set the head-complement parameter correctly and sometimes move the verb as high as I but fail to move it to C.

Table 3: Distribution of finite and non-finite verbs with respect to V2
German (Clahsen, Eisenbeiss and Penke 1996:
Simone 1;10-2;7, Matthias 2;3-3;6, Annelie 2;4-2;9, and Hannah 2;0-2;7)

	Simone	Matthias	Annelie	Hannah
finite/non-finite				
Vfin in V2	93% (511)	87% (69)	88% (117)	80% (4)
Vfin in final pos.	7% (41)	13% (10)	12% (16)	20% (1)
V-fin in V2	2% (4)	2% (1)	1% (1)	X

V-fin in final pos.	98% (189)	98% (52)	99% (80)	X

4.2.4. The Clitic Parameter

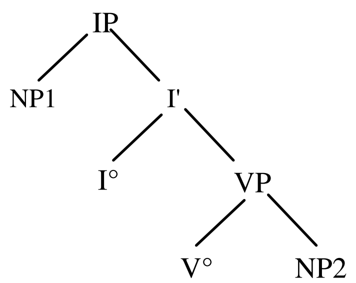
Romance pronominal clitics differ from full nominal and pronominal expressions with respect to a number of properties. Two of these are illustrated in (11) and (12) they cannot be used in isolation (11a,b) and cannot be separated from the verb (unless by another clitic) as in (12a,b). (see Kayne 1975 for the original discussion of these properties).

(11)a. Qui est venu? * Il
who is come He
'who came'
b. Qui as-tu vu? * Le
who have-you seen Him
'who have you seen?'

(12) a. *Il probablement viendra.
he probably will-come
b. *Pierre le probablement connaît.
Peter him probably knows

Because of their strong affinity to the verb, structure (13) has been proposed where the clitic position is associated to I°, the surface position of the inflected verb in French.

(13)



It has been observed for sometime that subject clitics occur early in the speech of French children and that they are always found in 'clitic' position.

Table 4: Occurrences of subject and object clitics in verbal utterances in the Augustin-corpus

Age (y;m,d)	verbal utterances	subject clitics	% of verbal utterances	object clitics	% of verbal utterances
2;0,2	57	17	29.8	0	0
2;0,23	30	4	13.3	0	0
2;1,15	22	4	18.2	0	0
2;2,13	55	16	29.1	1	1.8

2;3,10	45	12	26.6	0	0
2;4,1	62	10	16.1	0	0
2;4,22	54	11	20.4	1	1.9
2;6,16	116	25	21.6	2	1.7
2;9,2	175	80	45.7	10	5.7
2;9,30	115	99	63.4	22	14.2
total	771	278	36.1	36	4.7

In order to see whether the use and distribution of clitics is differentiated from the use of strong pronouns which can be used in isolation and generally have the properties of lexical nouns, Augustin's use of the non-clitic demonstrative pronoun *ça* was investigated. In the adult grammar, in addition to preverbal subject position, *ça* freely occurs as a post-copular predicate in the expression *c'est ça ('that's it')*, as a post-verbal object, as a prepositional object, in right and left dislocated position (particularly in the expressions *c'est beau, ça (it is nice, this)* and *ça, c'est beau (this, it is nice)*) modified by the universal quantifier *tout*, and in non verbal utterances, for instance as a short answer to a question. This wide distribution is mirrored exactly by Augustin's early production. Consider the examples in (14) and the results given in table 5:

(14) a. ça toune 'ça tourne' A 2;3,10
that turns

b. [teta] 'c'est ça' A 2;0,2
it.is that
'that's it'

c. manger ça? A 2;0,2
eat that

d. oter ça A 2;4,22
empty that

e. e fais ayec ça 'je fais avec ça' A 2;6,16
I do with that

f. c'est pour ça A 2;9,2
it is for that

g. [e kate ta] 'est cassé ça' A 2;4,1
is broken that

h. c'est quoi, ta 'c'est quoi, ça' A 2;6,16
it is what that
'what is it'

i. ça, c'est quoi? A 2;6,16
that, it is what

l. Qu'est-ce que tu veux enlever? - ça A 2;4,22
what is it that you want take away - that

m. Qu'est-ce qu' il y a encore dans la boite? - encore ça A 2;4,1
what is it that there has still in the box - still that
'what is there still in the box? that (is still there)'

n. Qu'est-ce que tu veux reparer? - ça A 2;6,16
what is it that you want to repair - that

Table 5: Occurrences of ça in different verbal environments in the Augustin-corpus

Age	Sub	Pred c'est ça	Obj	prep. Obj	comm e ça	right disl.	left disl.	tout ça	utt	total
2;0,2	2	1	4	0	1	1	0	0	0	9
2;0,23	0	0	3	0	1	3	0	0	1	8
2;1,15	1	0	0	0	1	0	0	1	0	3
2;2,13	1	0	0	0	2	0	0	0	0	3
2;3,10	1	0	1	0	5	3	0	0	2	12
2;4,1	0	0	0	0	3	2	0	0	1	6

Summing up these results on Augustin (2.0-2.10), Hamann, Rizzi, Frauenfelder (1996) found 281 occurrences of unambiguous clitics (*je, tu, il, on. ils, ce, me, te, se, le, les, y, en*) and all of them in clitic position. On the other hand there were 129 occurrences of *ça*, all in non-clitic position. So obviously, clitics were used and classified as clitics from the beginning of recording. (See also Hamann 2002)

4.2.5. Intermediate summary

We have seen that the head-complement parameter is set correctly by German (SOV) and English (SVO) children – visible in the order of infinitival main verbs and their complements. Likewise, French children raise finite main verbs across adverbs or negation to I whereas English children raise auxiliaries and modals but not main verbs. We have also seen that German (or Dutch) children reliably place finite verbs in second position (with a few exceptions), which indicates that they have recognized their language as a V2 language. Moreover, French children use clitic pronouns correctly from early on which shows that they have mastered and set the clitic parameter correctly.

Because of these and many other such results the general consensus is that parameters are acquired early, see also Wexler (1998) for more details. It should follow that the principles connected with these parameters are in place even earlier.

4.3. The Structure of Early Clauses

4.3.1. Children's early multiword utterances

The results mentioned in 4.2. make the acquisition process look very easy, and the acquisition of syntax could be taken as a free ride on UG. That this is not the case is apparent in those areas where non-adult structures are used systematically over several months or even years. Such areas are in particular the use of non-adult infinitives, the omission of auxiliaries, determiners and subjects found not only in English. The examples in (15) demonstrate the use of infinitives whereas those in (16) show subject omissions.

(15)	a.	him fall down	Nina	2;3	English
	b.	manger ça eat (inf) that	Augustin	2;0	French
	c.	Thorstn das habn Thorsten that have 'Thorsten has that'	Andreas	2;1	German
	d.	zo ikke in doen	Hein	2;4	Dutch

		so I in put			
		‘so I put (it) in (there)’			
	f.	hun sove	Jens	1;10	Danish
		she sleep (inf)			

(16)	a.	want more apple	Eric	2;1	English
	b.	oter tout ça	Augustin	2;1	French
		take off all that			
	c.	bin wieder lieb	Elisa	2;10	German
		am good again			
	d.	wordt al donker	Hein	2;6	Dutch
		becomes already dark			
		‘(it) is getting dark already’			
	f.	ikke k¢re traktor	Jens	2;0	Danish
		not drive tractor			
		‘I/you/he don’t/doesn’t drive the tractor’			

In (17) we detect the omission of auxiliaries, and in (18) determiners are omitted.

(17)	a. Eve gone	Eve	1.6	English
	b. Kitty hiding	Sarah	2.10	English

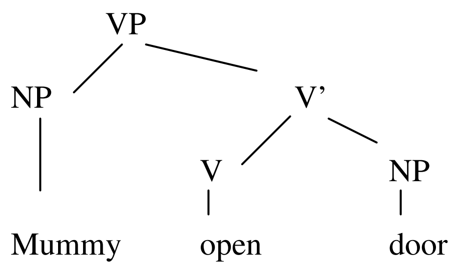
(18)	a. Open door	Eve		English
	b. Niekje ook boot maken	Niek		Dutch
	Niekje also boat make			
	c. tiens couteau	Louis	1.10	French

The use of structures like these resembles **‘telegraphic speech’** which has been used as a name for the typical child utterances in the third year of life (2.0-3.0).

4.3.2. Missing functional categories and the small clause hypothesis

Given these observations, it has been suggested that initially children do not have functional categories. This means in particular that the structure they project is the VP without the higher IP and that arguments are NPs not DPs as shown in (19).

(19)



The lack of IP explains the lack of past tense, of the 3rd person –*s* and the omission of auxiliaries very nicely. In the restriction to the VP this structure sees the child’s clause as a projection of the lexical properties of the verb in that it encodes nothing but the thematic relations between the verb and its arguments.

We know that adult grammar has functional categories and that they are an essential part of human language. Does this early lack mean that children have a grammar fundamentally different from adults? Is there no continuity? The term '**small clause hypothesis**' for early clause structure suggested by Radford 1990, shows that this is not necessarily the case. Indeed, a structure similar to that suggested in (19) can be found in adult clauses as in the complements of perception verbs, which have been called 'small clauses' because they lack the IP. Note that in (20a) the IP is not projected, whereas determiners are present.

(20a) I saw Mary eat an apple
(20b) *I see Mary have eaten an apple (20c) *I saw Mary could eat an apple.

Though the small clause hypothesis or even the idea that functional categories are simply missing seems to explain much of the English data, we have already encountered evidence that children project more than just the VP. Let us discuss this evidence.

It has been observed in several languages that children use finite verbs and infinitival constructions side by side (Wexler 1994). Note that the Danish examples show some of the earliest infinitives used by these children, and still in the same recording you also find finite verbs.

	+finite		**-finite**	
(21)	**German**			
a.	da guckt er raus	a'.	Thorstn das habn	
	there looks he out		T. that have	
	'there he peeps out'		'T. has that'	Andreas 2;1
b.	malt eier	b'.	**nich aua mache(n)**	
	paints eggs		not ouch make (inf)	
			'doesn't hurt'	Simone 1;10

	+finite		**-finite**	
(22)	**Danish**			
a.	kører bil	a'.	køre bil	
	drive (fin) car		drive (inf) car	
	'(I/he) etc. drive the car'		drive the car'	Jens 1;10,14
b.	sover	b'.	sidde der på	
	sleep(s)		sit there on	
			'sit there'	Jens 1;10,14
c.	**det gider ikke**	**c'.**	**nej, ikke have**	
	that likes not		no, not have	
	'it doesn't like'		no, have not	Jens 1;10,14
d.	det kigger	d'.	e kigge	
	it looks		e look	Jens 1;10,14
e.	græder	e'.	hun sove	
	cries		she sleep	Jens 1;10,28
	'she cries'			
g.	det lukker	g'.	du tegne	
	it closes		you draw (inf)	Anne 1;7,18
h.	der er det	h'.	gribe bold	
	there is it		catch (Inf) ball	
	'there it is'		'catch the ball'	Anne 1;7,18
i.	her er koppen	i'.	køre bil	
	here is the cup		drive car	Anne 1;8,22

j.	**det er ikke Annette**			
	that is not Annette			Anne 1;8,22
k.	sover	k'.	sove	
	s/he sleeps		sleep	Anne 1;9,09
l.	er færdig	l'.	læse	
	is finished		read	Anne 1;9,09
m.	jeg falder	m'.	jeg tegne	
	I fall (fin)		I draw (inf)	Anne 1;9,09

(23) **French**

a.	on joue ballon	a'.	oter tout ta	
	one plays ball		take off all that	Aug 2;0,02
	'we play ball'			
b.	est pour maman	b'.	manger maman	
	is for maman		eat maman	Aug 2;0;02
c.	veux jouer dinettes	c'.	donner n'ta [kitE]	Aug 2;0,23
	want play cooking		give (inf) that Christelle	
	'(I) want to play cooking'		give that to Christelle'	
d.	est beau	d'.	oter la coquille	
	is nice		peel the shell	Aug 2;0,23
e.	i' mange [a kup]	e'.	manger ça	
	'he eats ???'		eat (inf) that	Aug 2;0,23

The co-occurrence of non-finite and finite verbs is well-established. There are two possible ways to explain this and still claim that verbal functional material is missing.

It could be claimed that the finite forms are unanalyzed chunks for the child in the sense that the child has picked these up from the input but does not analyze them *as lexical verb + functional morpheme*. The infinitive and the finite form are therefore only variants of the same verb form for the child. This would mean, however, that for the child – who makes no distinctions – both forms can occur in the same environments, i.e. the distributions of infinitives and finite verbs should be the same. Table 1, 2 and 3 show that this is not the case. Moreover, the results presented in these tables, the examples in (9a-e), and also in the tables about clitic use show that French, German, and English children project the IP. (See also the exercises).

As a second objection, Radford has often mentioned that the optionality of finite verbs and infinitives is just an artifact of the late start of data taking and earlier data would reveal such a phase. He claims that in one of the early files of Nathalie, a Canadian French child, all the verbs are in the infinitive. It has to be mentioned that a close inspection of that file reveals that the analysis of so called infinitives included forms like '*njam-njam' –manger* for which it is not even clear whether these are nouns or verbs. Not counting these forms leaves Nathalie verb-less in that recording.

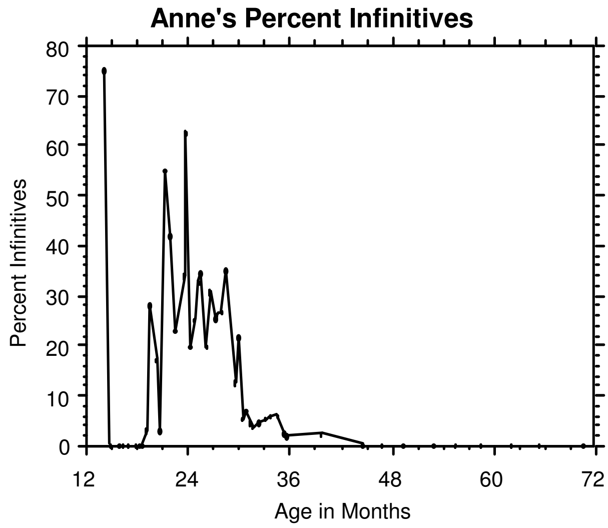


Figure 8a: Anne's Percent Infinitives

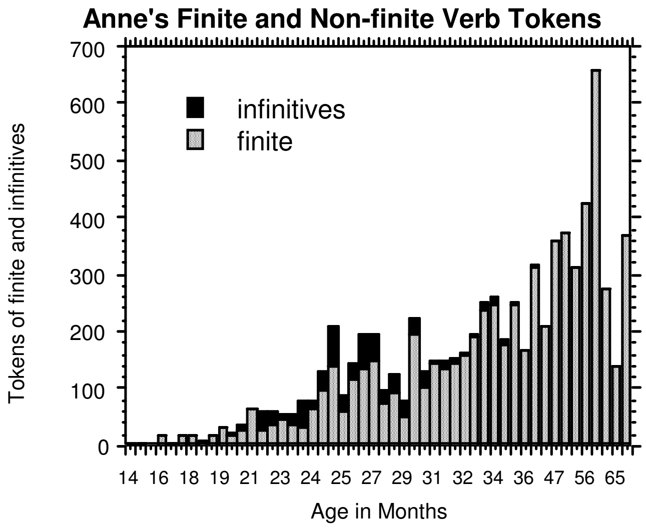


Figure 9a: Anne's Finite and Non-finite Verb Tokens

Even clearer evidence comes from the study of Hamann and Plunkett 1998 on the two Danish children quoted above. These children were recorded from their first till their sixth birthday. So recording started long before the multiword stage. It could be shown that these children do not start with the use of infinitives but that finite verbs are always the majority of the verbal utterances.

4.3.2. Full Competence

As an alternative to the small clause hypothesis it has been proposed that functional categories are present from the beginning. This hypothesis is known as **the full competence hypothesis** as it presupposes access to the full functional structure of the clause.

Many recent studies have shown that such an assumption is probably correct. However, adhering to the idea of full competence leaves researchers with the problem of explaining the obvious lack of structure manifest in the examples given above. Several proposals have been advanced which can be classified into extra-grammatical and grammatical approaches.

One extra-grammatical proposal appeals to prosodic properties and simply claims that unstressed syllables are omitted by children (Gerken 1994). This would explain syllable omission on the word level and the omission of functional material because such material is mostly unstressed. Another extra-grammatical proposal appeals to the limited working memory and processing capacity of children in suggesting that material is omitted if the processing load gets too heavy (Bloom 1990).

Grammatically oriented approaches have suggested that there is an initial **parameter missetting** – which might lead children to behave as if they were in an Italian or Chines grammar and omit subjects or articles (Hyams 1986). Alternatively, functional categories have been suggested to be present but **underspecified**. If the I node is not endowed with the proper tense features, verbs will not be marked for tense and may surface as infinitives (Wexler 1994, Hyams 1996). Another possibility is that children are as economical as possible – due to their processing restrictions – and project only what is necessary. So they may only project the VP, but in the next sentence they may decide to mark the verb with tense and will therefore project as far as IP. For a question they will have to use the CP in order to place the Wh-word, but for a declarative they will project only as far as IP or VP (in English but also in German). A proposal along these lines has been advanced by Rizzi (1994, 2000) who assumes that children cut off or **truncate** structure.

An important help to decide between extra-grammatical and grammatical approaches is the evidence of distributional restrictions perceived for such omissions. A processing account or a prosodic account has to add assumptions in order to explain that subjects are omitted in English, but not objects, that subjects are omitted only from sentence initial position but not from questions, or that determiners are more often omitted on subjects than on objects. Such observations provide crucial evidence because they show that the phenomenon in question is structure dependent. Another indication that the cause for a certain phenomenon – say subject omission – is likely to be grammatical is its co-occurrence in time with another grammatically related phenomenon. In such a case, it is likely that an underlying grammatical factor determines both. This is the case with the use of infinitives and null subjects which are closely related.

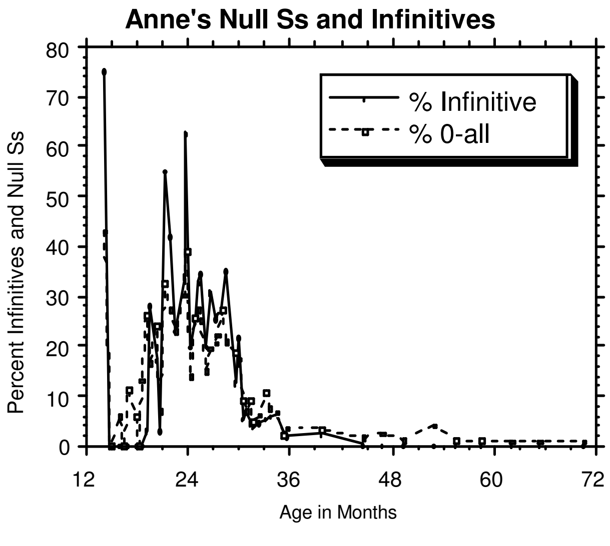


Figure 11a:Anne's Null Subjects and Infinitives

from Hamann and Plunkett 1998

Given such evidence, it is clear that hypotheses about syntactic development have to be preferred which can explain the regularities pertaining to the phenomenon as well as correlations to other phenomena. Much current research is devoted to empirical studies establishing such evidence and therefore the last word about the acquisition of syntax has not been pronounced.

4.4. Summary

Whereas parameters are set very early, children use **telegraphic speech** for about a year. There are several attempts to explain this phase within the boundaries of UG. One approach suggests that **early clauses are small clauses** and that only the lexical, thematic properties are projected.

Evidence from child corpora of several languages argues against this hypothesis. Infinitives and finite verbs co-occur in the corpora and it can be shown that children distinguish finite and non-finite forms (only finite verb forms are raised in French or German, only finite verbs occur with subject clitics in French). It is therefore more likely that children have functional categories from the start and in this sense have **full competence**. This leaves telegraphic speech to be explained. The fact that omissions are grammatically restricted to certain contexts and the existence of correlations between the observed phenomena argue for grammatical explanations of these early structures, the mis-setting of a parameter, the underspecification of certain functional categories, or a truncation strategy.

Recommended Reading:

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