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Language in the infant’s mind

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SUMMARY
We review recent work that shows that, during the early stages of language acquisition, molar properties such as prosody are important to the infant. We argue that the specification of these structures allows the infant to learn the language processing routines that adults employ.

1. INTRODUCTION
Some years ago, Mehler (1981) proposed that the syllable is a molar structure that plays the most salient role during speech processing. After reviewing limited empirical observations, he concluded that these structures play a central role in language processing and are independent of any specific language.

Today, the database has grown dramatically and it is difficult to maintain the proposal. However, we have not been led to some sort of late quasi-cognitive shift of attention or bias rather than to specific modular language-processing routines (Best et al. 1988). However, psycholinguists have recently begun to focus on how these phonemes are organized into larger structures and how these larger structures play a role in speech processing. For instance, the data indicating that syllables intervene in language processing seem quite strong (Cutler et al. 1983, 1986; Dupoux & Mehler 1989; Sebastian-Galles et al.)
acquires the right processing algorithm to become optimally efficient when listening to speech. In this paper we will present some recent results pertaining to how this is done. First, we provide a short overview of some facts about speech acquisition that are more or less accepted by all the workers in the field.

1. The brain is specialized to process speech at birth differently from other acoustic stimuli. Anatomical and functional studies have shown that the asymmetric organization of the brain at birth corresponds to a functional asymmetry by which speech stimuli are processed with a left-ear advantage and many other acoustic stimuli with a right-ear advantage or without any asymmetry at all (Entus 1977; Best 1988; Bertocci 1989).

2. The neonate has the ability to track voices and recognize some of them within only a few days of birth. In a series of experiments it has been shown that the infant is able to react distinctively to a given voice. The general finding is that infants have a precocious recognition of their mother’s voice (Mills & Meluish 1974; Mehler et al. 1978; DeCasper &ifer 1980). This shows that the infant is able to single out and attend to one speaker.

3. The child is born with the endowment to operate all the contrasts that arise in natural languages. Research over the past twenty years has established that the neonate has the ability to discriminate stop consonants that differ by just one distinctive feature, such as voicing (Eimas et al. 1971), place (Eimas 1974) or manner (Eimas 1975).

4. During the first year of life the baby is sensitized to the sounds of the native language. By six months the child changes so as to remain sensitive, attentive or able to process differentially the vowels of his or her maternal language (Kuhl et al. 1992). The same process seems to take longer for consonants that are distinctive in the parental language (Werker & Tees 1984). In short, there is no evidence that the process of phonetic to phonemic convergence starts before the baby is six months old and there is a considerable amount of evidence showing that the process is well advanced by the time the baby approaches the end of its first year of life.

2. TUNING TO THE MATERNAL LANGUAGE, OR THE PROBLEM OF MULTILINGUAL ENVIRONMENTS

We have already sketched some of the results that show that language processing is speech-specific. The question that ensues is: how does the infant discover the structures that are essential for learning the maternal language? Once such a question is asked there is another one that is even more puzzling: how can a child raised in a multilingual environment avoid the fatal confusion these circumstances should cause? Indeed, if the child considered utterances drawn from several languages to arise from the same underlying structure, he or she would be unable to find a lawful structure that would match the requirements of both sets of sentences at the same time. If this were true, the infant would never learn language. So, what mechanisms protect infants from falling into confusion when raised in multilingual environments?

Bahrick & Pickens (1988) have shown that infants four months old notice a language change when tested with the habituation–dishabituation paradigm. Infants habituated to an English sentence and tested with a novel English utterance dishabituated less than experimental subjects who were tested with a Spanish sentence.

Mehler et al. (1988) studied the ability of French-born infants four days old and American-born infants two months old to notice a language change when presented with sets of varied sentences. They found that French newborns could discriminate Russian from French utterances. The authors also found that these newborns displayed greater sucking rates when listening to French than when listening to Russian. This result was explained as a preference for the maternal language, or, more neutrally, that French is a more familiar stimulus than Russian. Moreover, French newborns were able to discriminate English from Italian utterances (see Mehler & Christophe (1994) for a re-analysis of the original data). Comparing the neonates to the older infants, the authors reported that American infants two months old had a discrimination behaviour that contrasted with that of French newborns: they discriminated English from Italian sentences, but failed to discriminate Russian and French sentences. No reaction to familiarity as evidenced by greater sucking rates for English was found in these older infants.

In brief, at four days of age, infants are able to distinguish sentences drawn from two different languages, regardless of whether one of the two languages is familiar to them. The behaviour of the infants two months old differs interestingly from that of neonates. Indeed, at this age, the infants are only able to discriminate a language change when one of the languages is familiar to them. This suggests that the ability to sort utterances according to the language from which they are drawn changes during the first two months: while younger infants try to classify any sentence-token into a language-type, the older ones classify utterances as belonging either to their maternal language or to an undefined foreign type.

Below, we argue that infants construct language-types on the basis of prosodic structures, suggesting that, by the age of two months, they have specified some of the distinctive properties of their maternal language. When sentences from two different unknown languages (even with different prosodic types) are presented, the infant treats both of them as fitting an unfamiliar model.

Mehler et al. (1988) also showed that infants, neonates and those two months old, discriminate a change in language when they listen to lowpass filtered speech that permits frequencies below 400 Hz (that is, overall properties of utterances such as intonation and rhythm) while filtering out most of the higher-frequency components (those that carry phonemic information). This observation strengthens the hypothesis that infants embark on the acquisition
of language by paying attention mainly to the prosodic properties of speech. A consequence of this disposition is that it facilitates the classification of inputs according to the natural language from which they are drawn. It is much more difficult to decide from the above studies whether infants already react as if their maternal language was more familiar to them shortly after birth or whether such behaviour develops a few months later. Two recent experiments bear specifically on this issue.

Moon et al. (1993) assessed the preference of infants two days old, tested with Spanish and English sentences. Although all the mothers were monolinguals, half of them were Spanish-speaking and half American. Infants sucked during three periods of six minutes each. Moon et al. report that all infants sucked more during the third period, when they were listening to their mother’s native language, than when listening to the other language. The authors interpret this behaviour as showing that infants two days old prefer the native language of their mother.

G. Dehaene-Lambertz (in preparation) has adapted a method previously used to study visual preference (Johnson et al. 1991) to assess preference for auditory stimuli in two-month-olds. Dehaene-Lambertz used French and English utterances of less than 3s duration. Utterances were presented either in their original form or after having been lowpass filtered. The results show that American-born infants start moving towards the side of the English utterances significantly faster than to the French ones. The latency advantage to orient to the English sentences is comparable for both filtered and unfiltered utterances. This ability of American infants two months old to orient faster towards English utterances of a language relate to durational, energetic and pitch parameters that induce the perception of rhythm, stress and intonation. We hypothesize that there exist classes of natural languages that differ with respect to their prosodic characteristics. Thus, we entertain the hypothesis that infants first tune to a subset of languages and only at a later stage do they converge to the precise language spoken by their parents. Up to now, we have seen that infants use prosody at the level of whole sentences to keep languages apart. We shall now turn to the second main problem that the newborn infant encounters in the very first stages of language acquisition, namely segmenting the continuous speech stream into linguistically relevant units. There, too, prosodic structure may help the infants to bootstrap language acquisition, although this time at a level that specifies smaller units.

3. TUNING TO THE PROSODIC UNITS OF ONE’S MATERNAL LANGUAGE

The structure of language is discrete at several levels of structure, i.e. we compute the meaning of sentences by identifying phrases and operating on individual words. There is thus no doubt that, on hearing utterances, speakers of a language have to access individual words. If we now think about the task facing the infant hearing a language, it is clear that acquiring the lexicon is a necessary stage of learning, because the sounds that languages use to refer to things are extremely idiosyncratic. However, even superficial inspection of the speech stream shows that it is continuous, and that there are no pauses between words. Some models of adult speech perception take this fact at face value and offer mechanisms via which
utterances interrupted either at a boundary between two constituents, or somewhere within a constituent. To test the infants they relied on a modified version of Fernald's preference looking paradigm (Fernald 1985). Studies with American infants 9 months old, 6 months old and even 4.5 months old show that they prefer listening to speech that has pauses between clauses rather than pauses that interrupt clauses. Moreover, American infants 4.5 months old also prefer to listen to an unfamiliar language like Polish with interruptions that preserve the integrity of clauses (P. Jusczyk, D. Kemler Nelson, K. Hirsh-Pasek & T. Schomberg, in preparation). The authors suggest that the clause's integrity is signalled both by temporal and frequency cues, and that these cues may well be universal. Indeed, in languages as different as English and Japanese, clause boundaries are marked by a fall in pitch, and a lengthening of the last segments of the clause (Fisher 1991).

Jusczyk et al. (1992) investigated whether infants were also sensitive to units smaller than the clause. To explore this issue they placed pauses in utterances, either at the major syntactic boundary, namely between the subject and the verb, or at a minor syntactic boundary, generally between the verb and its complement. Jusczyk et al. report that infants 9 months old, but not those 6 months old, prefer listening to stories with the pause at the major syntactic break. This result is difficult to interpret. Indeed, in some cases the break between subject and verb does not correspond to a major prosodic break.

The studies carried out with infants seem to be highly dependent on the method that is used to assess their competence. Indeed, there is evidence from other paradigms, i.e. using lists of words instead of long samples of continuous speech, that infants younger than nine months have some knowledge of the prosodic configuration of the words of their maternal language. We take this as indirect evidence that infants are sensitive to prosodic units smaller than the phonological phrase before nine months. We will cite here two such studies.

Jusczyk et al. (1993b) report that American infants 6 months old show a preference for lists of unfamiliar English words compared with Norwegian words uttered by a single bilingual speaker. However, these infants shown no preference for lists of English as opposed to Dutch words. Moreover, these results hold when the words are lowpass filtered, indicating that the infants rely on the prosodic properties of the words. The authors stress the fact that the prosodic properties of English and Norwegian words are radically different (for instance, in Norwegian pitch tends to rise at the end of words), while English and Dutch words have similar prosodic properties. This study indicates that infants 6 months old have a notion of what is a legal prosodic unit in their language, even though these prosodic units are only two syllables long.

Jusczyk et al. (1993a) have raised a similar question in relation to stress. As Cutler and her colleagues have argued, most content words in English start with a
does not have to acquire them. In contrast, smaller prosodic units are not universal. Their form, and the way they are disjoined from one another, are all things that have to be acquired by infants. So far we do not have any notion of how they do this nor at what age the different units become available. We hypothesized that infants come prepared to segment speech into the relevant units regardless of language. Although the units may not be universal, they might fall into natural classes that the infant can characterize without too much trouble.

To investigate further the hypothesis that prosodic information is used by infants at a very early age to segment the speech stream into linguistically relevant units, Christophe et al. (1994) tested whether newborn infants are sensitive to the prosodic cues that might mark prosodic units. Christophe et al. (1994) used bisyllabic CV.CV contexts that either did or did not include a phonological phrase boundary. All bisyllabic contexts were phonemically identical (e.g. mat), and spliced out from sentences where they were the two middle syllables of a long word (e.g. mat in ‘mathématicien’), or the last syllable of a noun and the first of the following adjective (e.g. mati in ‘panorama tibétain’). Measures of the prosodic parameters of the stimuli showed a significant word-final vowel lengthening, which is not surprising since French is an accent-final language. A significant word-initial consonant lengthening was also measured. French infants 4 days old were tested with the high-amplitude sucking procedure, and the results show that they were able to discriminate the CV.CVs that contained a phonological phrase boundary from those that did not. This result was replicated with another bisyllabic context, menta, produced by another speaker.

To summarize, we have found that infants during the first year of life acquire a knowledge of the shape of the word-sized prosodic units of their maternal language (as early as six months for gross prosodic features, and nine months for finer representations). Furthermore, we reviewed studies that show that to ‘timing-units’. According to Fant and his colleagues, for each language ‘there can be a different basis by which a significant proportion of the variance in durational measures of speech can be accounted for’ (Fant et al. 1991). Traditionally, French, English and Japanese are described as syllable-timed, stress-timed and mora-timed, respectively (Abercrombie 1967). The traditional description captures the phenomenological experience reported by speakers of those languages. However, there is a compelling need for more data to support the above statements. Recent data from on-line psycholinguistic experiments suggest that parts of the processing routines of listeners depend on their maternal tongue, and in particular on the prelexical unit that is most prominent in their maternal tongue. To understand how speakers discover the pertinent routines for their language, we have to start by investigating the initial state.

We know from work by Starkey & Cooper (1980) and Antell & Keating (1983) that infants are able to represent the numerosity of sets of small cardinality. Bijeljac-Babic et al. (1993) capitalized on that work to assess whether infants represented the number of syllables in simple CV sequences. They habituated infants to a list containing either varied bisyllabic or varied trisyllabic items whose composition was CV.CV and CV.CV.CV respectively (a speech compression–extension algorithm was used to diminish the difference in duration to a negligible magnitude). In the post-shift phase, the infants who had been habituated on bisyllabic items were presented with one of the following two situations: either they continued hearing bisyllabic items (control condition) or they were shifted to the list of trisyllabic items (experimental condition). Reliable discrimination was observed; this result indicates that infants react to the number of syllables in lists of stimuli, even in the context of wide phonemic variation.

The above results suggest that infants behave as if they had represented the number of CVs per item, or some other configuration that correlates with number
newborns noticed the addition of a new syllable only when it differed from the other syllables by its vowel. The salience of the vowel seems to be so critical to very young infants that under tests like the one described, the newborns even failed to notice the addition of the syllable /is/ in the context of /bi/, /si/, /ti/ and /mi/. This series of experiments adds to our conviction that during the earliest stages of language acquisition vowels are central to the infants' representations.

However, it would be premature to dismiss the syllable as a good candidate for the representation that infants construct during the habituation phase of the Bijeljac-Babic et al. (1993) experiment. Bertoncini & Mehler (1981) demonstrated that syllables have special status in the discriminations that infants 1 month old operate. This result was recently corroborated by Mood et al. (1992) using a very different property as responsible for the infants' behaviour. At all three levels considered, we referred to prosodic

nature of inputs. Rather, the linguistic stimulation they receive is organized into files in which knowledge of different phonologies is compiled. We have also shown that the baby precociously builds a template that makes it possible to rate inputs as belonging to the familiar system or as being foreign. Next, we turned to the segmentation problem, and showed that there is good evidence that infants build prosodic templates for word-sized units of their maternal language during the first year of life. Research on neonates suggests that even at birth infants are already sensitive to cues that demarcate prosodic units. Last, we reviewed existing experiments that inform us about the early representations that infants construct. We outlined an early predominance of vowels in these representations.


Moon, C., Cooper, R. & Fifer, W. 1993 Two-day-olds prefer their native language. Infant Behav. Dev. 16, 495–500.


