Psycholinguistic implications of phonological diversity among languages

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INTRODUCTION

Psycholinguistics in Europe is thriving. Small wonder: Europe offers an ideal environment for psycholinguistic research. In a relatively tiny geographical area we find an abundance of different languages, and a plethora of bilingual and multilingual communities. Moreover, the languages differ widely. Although in some parts of the world there may be more distinct languages spoken in an equivalently restricted area, it is usually the case that such languages belong to the same language family or to closely related families, this is not necessarily so in Europe. Finnish and Swedish, Basque and French, Russian and Estonian - the co-existence of widely diverging languages within a single community is far from uncommon.

One result of this can be seen in psycholinguists' awareness of the applicability of their models. If a model is developed exclusively on the basis of data from a single language, it is destined to fail when applied to other languages with very different structural characteristics. Psycholinguists find it hard to ignore this fact when they live and work among structurally different languages, or are well aware that different languages exist but a few miles from home. A concern for questions of universality versus language-specificity, and a strong predilection for cross-linguistic investigations, have, therefore, become characteristic of European psycholinguistics.

Another consequence is a lively interest in the topic of bilingualism. In many European countries, bilingualism or even multilingualism is the norm. The completely monolingual speaker-hearer as conceptualised in much psycholinguistic research is probably in the minority in contemporary Europe. Predictably, therefore, European psycholinguists have tended to address questions of language use and language acquisition from a broad and comparative perspective.

In this paper, we review a tiny part of the research of this type. We concentrate

on research that examines the effects of diverse phonologies on language processing. How is the way we speak and understand our native language constrained by that language's phonology?

1. THE RECOGNITION OF CONTINUOUS SPEECH.

The processing of continuous speech amounts in essence to the identification and recognition of individual words. Obviously, listeners have enormous difficulty extracting any information at all from a stream of speech in a language whose lexicon they do not know. So there is no doubt that in one sense words are the basic units used to understand language. But in most languages words can vary widely in length and phonological patterns, making extraction of words from a continuous speech stream far from easy. Psycholinguists have therefore paid a great deal of attention to the question of whether there are fundamental units of speech perception which are defined purely on the basis of the structure of speech sounds - phonological structure.

The fact that languages differ widely in phonological structure obviously suggests that if such units are discovered, they may play different roles in the processing of different languages. Indeed, there may even turn out to be different fundamental perceptual units for different languages.

Casual observations certainly suggest that language phonology plays a major role in the initial segmentation of a continuous speech stream prior to word identification. Consider a listener presented with speech in a foreign language; the listener's experience differs as a function of the phonological similarity between the foreign language and the listener's own language. If the two languages are phonologically very close, the listener can often secure some representation of the acoustic-phonetic content of the message; the phenomenal experience is something like listening to non-words in the native language. In contrast, utterances in a phonologically distant language are very difficult to process. The listener's impression is often that the utterance went by too fast to enable computation of even an impoverished acoustic-phonetic representation.

Of course, phonological distinctions absent from our own language are very difficult to perceive in a foreign language. Thus Japanese speakers find it very difficult to discriminate between the /r/ and /l/ phonemes used in English and French. Likewise, French speakers have great difficulty in detecting and remembering where stress appears in English words. A huge amount of research has been devoted to how the infant narrows down the potential phonological space to establish a native phonology, and how, once established, that phonology forms the framework within which both native and foreign utterances are thereafter

processed. Recent investigations, however, suggest that the influence of native phonology on perceptual processing goes beyond the establishment of passive categories according to which input may be classified; the basic perceptual units used in speech segmentation may also be constrained by language phonology.

The search for basic speech processing units has exercised experimental psycholinguists for decades. One obvious question has been whether the units of phonological structure which linguists have established also serve as processing units for speakers and listeners. The basic linguistic unit could be said to be the phoneme, in that it is the minimal unit of sequential occurrence. However a study by Savin and Bever (1970) cast doubt upon the processing reality of the phoneme, by showing that listeners detected syllable targets (e.g. PA) faster than phoneme targets (e.g. P). Savin and Bever argued that syllables are the basic units of on-line processing. Their study was conducted in English; the same result holds for French (Segui, Frauenfelder & Mehler, 1981). Mehler, Dommergues, Frauenfelder and Segui (1981) provided further evidence of the importance of the syllable as a processing unit Again using French stimuli, they measured how rapidly listeners detected a specified syllable-sized target in word-initial position. The results showed that a target such as PA or PAL can be responded to more rapidly if it corresponds exactly to a syllable in the word in which it occurs (e.g., PA in PAlace, but PAL in PALmier). To explain these observations, Mehler et al. proposed that the syllable was the basic universal unit for speech perception. The listener segments signals in terms of syllables. Lexical search is initiated in terms of such syllables in a serial fashion.

This view was supported by many other observations in French. For instance, initial phonemes are identified on the basis of lexical information in words which consist of a single syllable (Cutler, Mehler, Norris & Segui, 1987), but apparently on the basis of acoustic-phonetic information in polysyllabic words, since a word frequency effect can be found with word-initial phoneme-monitoring for monosyllables but not for bisyllabic words (Dupoux & Mehler, 1990). This result is even more striking in that it does not change even when the items are compressed at a rate of 50% (making the bisyllabic items shorter than the average uncompressed monosyllables).

The usefulness of the syllable as a pre-lexical representation in the processing of French speech therefore seems well-founded. But in English the picture has turned out to be quite different Cutler, Mehler, Norris and Segui (1986) found that the Mehler et al. (1981) finding could not be replicated in English; in both *palace* and *palpitate*, response times to PA and PAL targets were the same. Moreover, the English listeners did not replicate the Mehler et al. result even when they were presented with the original French stimuli - again they showed in both types of

word similar responses to each type of target It appears, therefore, that English listeners do not syllabify, regardless of whether they are listening to French or to English words. French listeners, however, proved able to syllabify even English - so in *palpitate,* of which the first syllable is *pal-,* PAL targets produced faster responses than PA.

Cutler et al. called upon phonological structure to explain the different performance of the two subject populations. French has often been described as a syllable-timed language, English as a stress-timed language. In fact, speakers of French are quite sensitive to, and show a great deal of knowledge about, the syllabic structure of their language. In contrast, English speakers are often very unclear about the syllabic analysis of words in their own language. In particular, intervocalic consonants are often heard as belonging to two syllables at once, especially when the first syllable bears stress (e.g. the 0] in *palace)'.* Stress, on the other hand, is a salient feature for English listeners, if only because it can play a lexically distinctive role (consider the difference between *insight* and *incite,* for example).

The role that the syllable plays in French and stress plays in English is in determining the basic rhythm of speech. If the basic processing unit for French is the same as the basic rhythmic unit, could a similar connection between rhythm and initial perceptual processing exist in other languages?

Indeed, it does appear that the stress rhythm of English is used by English listeners in initial perceptual segmentation. The most salient aspect of stress rhythm is the contrast between strong syllables (syllables bearing primary or secondary stress, and containing full vowels) and weak syllables (unstressed syllables, with reduced vowels). Cutler and Norris (1988) demonstrated that English listeners segment speech at the onset of every strong syllable; further evidence of this, including evidence from spontaneous misperceptions in conversation, was provided by Butterfield and Cutler (1988). In English, a very large majority of lexical words begin with strong syllables (Cutler and Carter, 1987); thus if listeners assumed that strong syllables denoted the onsets of lexical words, they would rarely be wrong. For this reason, Cutler and her colleagues argued that the use of strong syllables as segmentation cues in the recognition of continuous speech is a natural, and efficient, procedure for English listeners. The basic rhythmic structure in the phonology of English has therefore provided the foundation of a basic processing procedure for English speech recognition.

Given this demonstration of stress-based segmentation in English, it was not surprising that Norris and Cutler (1988) found that Savin and Bever's (1970) finding described above was not after all reliable for English; the 1970 study had been inadequately controlled. Although presumably still reliable for French,

syllabic processing at early stages of perception can not be demonstrated in English. The equivalent of the syllabic segmentation which French listeners employ is, for English, stress-based segmentation instead.

The status of the English procedure does not appear to be directly equivalent to that of the syllable in French, however. Perhaps the main virtue of using strong syllables as anchor-points for speech segmentation in English is that this procedure offers a way around the difficult problem of locating word boundaries, for which there are in English virtually no reliable cues. In French, however, word boundaries are often quite clearly marked by tonic accents. Recent pilot work by Christophe & Mehler has found that babies and adults can tell whether a CVCV environment (e.g. [mati]) contains a word boundary between the first V and the second C (as in *panorama typique)* or not (as in *mathematique).* At this time we do not know whether performance would be comparable if one could replicate the experiment with equivalent English stimuli and English subjects. Evidence from a study of the perception of noise-masked speech, however, suggests that English listeners can use cues in stress rhythm to locate word boundaries (Smith, Cutler, Butterfield & Nimmo-Smith, 1989).

Not only the basic perceptual units, therefore, but also the kind of approach taken to speech segmentation may well be determined by the phonology of the language one grows up speaking. In short, a very preliminary morale that can be drawn from these findings is that exposure to a language in the course of acquisition may determine in a variety of ways the nature of the processing routines later used in perception.

Further evidence of the possible variety comes from recent studies with Spanish and Catalan. Sebastian, Dupoux, Segui and Mehler (1990) conducted studies which paralleled those of Mehler et al. and Cutler et al. for French and English. Working with Spanish and Catalan allows an assessment of the effect of stress in the target-bearing syllables, since both Spanish and Catalan have syllabic rhythm but also allow stress (though they are not stress languages in the same way that English is). Both languages have a predominance of penultimate stress, but other stress placements are also possible. The results of Sebastian et al.'s studies suggest that when the initial syllable of the target word is stressed, word-initial targets are responded to faster if they are CV rather than CVC, regardless of the syllabic structure of the target word; this is true for both Spanish and Catalan. When stress falls on the final syllable of the target word, Spanish still shows an overall latency advantage for word-initial CV targets regardless of syllable structure of target word; Catalan, however, does not Instead, Catalan produces results just like those previously found for French - an interaction between target type and syllable structure of target word. It is as yet too early to

draw general conclusions from these findings (although the results with the stressed first syllables may be interpreted as indicating that when acoustic-phonetic transparency is adequate, subjects can detect subsyllabic targets faster than syllabic ones). How are we to interpret the results with the stress in the final syllable? Perhaps in terms of the very same notion of acoustic-phonetic transparency. Spanish has only five vowels; Catalan has a much larger number. Thus distinguishing the realization of a CV or CVC target from that of potential competitors should be easier in Spanish than in Catalan. By the time the response is generated in the case of Catalan, it has had time to be affected by the syllabic structure of the target word.

Dupoux (1989) has argued that every language determines the optimal length of the segment upon which listeners rely in segment monitoring tasks such as those used in the studies we have described. Dupoux reanalysed data from many of the above investigations, and found that the variables affecting responses differ at different response latencies. In the study of Mehler et al. (1981), for example, only slower responses were affected by the syllabic nature of the target bearing items; faster responses seemed to be sensitive only to the syllable onset and nucleus. Dupoux argued that speech perception consists of separate phases. In an early phase, the perceptual systems have access to as much of the signal as is needed to effect the monitoring response; only in a later phase does the perceptual system integrate enough information to access the lexicon.

Obviously, the views espoused by Dupoux are mainly relevant to studies of French speech perception; but it is interesting to note that this position would be compatible with some results recently reported for English by Treiman (1983) and by Treiman and Zukowski (1990), in which syllabic processing, clearly absentfrom monitoring studies with English listeners, can be demonstrated in tasks which tap much later processing stages.

The full picture is as yet not drawn. But the combined results from the studies we have described suggest that listeners use different processing procedures according to the nature of specific phonology they learned during language acquisition. In English segmentation is guided by information relating to stress, in French by syllabic information, while in Spanish the relevant unit may be the demisyllable (CV). For all we yet know, a host of other procedures may be avaible for other types of languages.

2. SEGMENTATION IN BILINGUALS.

Having established that different processing procedures are used by speakers of English and of French, we were naturally led to ask whether more than one such

procedure can be available to a single individual. For instance, do bilinguals have access to several processing systems, each one adapted to the language they happen to be listening to? In order to answer this question, Cutler, Mehler, Norris and Segui (1989) carried out a study of highly bilingual speakers, who had equally good command of both English and French. We used several criteria in selecting these subjects. First, their competence, as assessed by native speakers of each language, had to be excellent; second, they had tohave acquired each languge early in life; third, both languages had to be used regularly from time of acquisition up until the time of testing. We used the same tasks that had been used to explore processing by monolingual French and English speakers, as described in the previous section; these French-English bilingual speakers performed syllable-monitoring for CV and CVC targets in French (where the target words were like *palace* or *palmier)* and in English (where the target words were like *palace* or *palpitate).*

The overall results for the bilingual population were rather difficult to interpret. For neither set of language materials did the bilinguals' performance closely resemble the performance of either the French or the English monolinguals. We therefore further analyzed the data as a function of several parameters along which our subject population could be subdivided. One of these was our subjects' country of residence at time of testing; again the analysis did not produce results which were comparable to those of the original studies with monolinguals. The same was true of an analysis in which the group was subdivided by the father's language; subdivision by the mother's language also failed to produce a completely interpretable pattern of results (but see below).

The parameter which did produce a fully interpretable pattern of results was, unexpectedly, the answer which subjects gave to a forced choice question about their dominant language. Subjects were required to select the language they would prefer to keep if they had to give one up. Although they found the choice very difficult (since they claimed to be equally at ease with either language), all subjects did make a choice, and we held their choice to be their "dominant" language. An analysis in which the bilingual group was subdivided in this way showed that French-dominant bilinguals segmented the French words syllabically; English-dominant bilinguals did not. For the English words, neither group used syllabic segmentation. Thus the English-dominant bilinguals looked just like English monolinguals - they failed to use syllabic segmentation either with French or with English words. The French-dominant bilinguals did use syllabic segmentation with French words, but unlike French monolinguals, they failed to use it with English words.

If one takes these analyses at face value, the French-dominant group appears

to be more flexible than the English-dominant one. However this pattern is, in all likelihood, merely an artefact of the tests that we used. These tests, chosen to be exactly parallel in French and in English, and to be usable with monolinguals in either language, allow the typical French processing procedure, syllabic segmentation, to appear if a subject commands it But they offer no scope for alternative procedures. In particular, they offer no scope for the stress-based segmentation procedure which, we have argued, is the analogue in English listeners of the French listeners' syllabic procedure. We suggest, therefore, that these studies show that procedures like syllabic segmentation are highly language-specific optional processing routines designed to increase speech segmentation efficiency. Any such procedure is available if a speaker's dominant language encourages it; but only one language can be dominant and hence only one such procedure can be developed. In bilinguals, sufficient exposure to a language for which the procedure does not work well will lead to it being abandoned with input in the non-dominant language. Thus our French-dominant bilinguals do not use syllabic segmentation when listeningto English. Our English-dominant bilinguals do not use it at all, because it is simply not available to them. On the other hand, we assume that they do have available to them the stress-based procedure, and that if tested with a stress segmentation task such as the one used by Cutler and Norris (1988) they would produce results equivalent to those ofEnglish monolinguals (while the French-dominant bilinguals, who presumably do not command the stress-based segmentation procedure, would fail to show evidence of it in such a task). Further research is planned to test this suggestion.

Given the rather modest bilingual population which we were able to study, the results to date must be treated with caution. However, a similar pattern of results was also found for bilinguals in the study of Spanish and Catalan by Sebastian et al., mentioned above; this strongly encourages us to pursue this line of exploration. Moreover, our findings, if they prove reliable, couldhavewide-rangingimplications. Humans can acquire numerous languages; it is generally believed that if they do so before puberty or adolescence the bi-, or multilingualism they develop will be "perfect". Perfection in this sense is often assumed to imply that both production and perception in each one of the languages mastered by the bilingual is exactly equivalent to the same processing for each of the respective languages in monolinguals. Our results suggest that this is not really the case. Perceptual processing seems to be determined by one, and only one, of the languages which the bilingual mastered early in life. Note, incidentally, that in terms of the range of the world's languages, French and English are relatively close; Spanish and Catalan are even closer. One might speculate that "perfect" bilingualism might be even more unlikely where languages are less alike (as in the case of an Indo-

European and an African or Amerindian language).

Finally, we acknowledge that the parameter of dominance which we called upon in interpreting our results is far from satisfactorily defined. The variable which correlated most strongly with dominance was, as it happens, the mother's language. It is certainly reasonable to suggest that during early infancy language processing procedures are determined by experience, and that the mother's speech is most likely to be the most frequently encountered input during this period. In our results, however, mother's language is not perfectly correlated with response patterns; only dominance is. We do not know whether for some of our bilingual subjects the mother was not the primary caretaker at some stage during early childhood; again, further research will be necessary to establish the exact nature of the dominance parameter. Some ways in which this issue might be approached appear in the next section, in which we consider data on language acquisition in very early infancy.

3. INFANTS AND LANGUAGE COMPETENCE.

In the last few decades linguistics has strongly influenced research in developmental psychology. As Chomsky (e.g. 1968) has argued, there is a great deal of evidence that the human language ability owes its existence to a biological machinery that is specific to the species (much as echo-location is specific to the bat, or wings to avians). Psychologists influenced by these arguments have looked in detail at the very earliest moments of language processing.

As a consequence of this, a number of procedures for experimental assessment of speech perception in very young infants have become available. The most successful method used with neonates is the Contingent-High-Amplitude-Sucking procedure, which was initially developed at Brown University by Siqueland & DeLucia (1969) and by Eimas, Siqueland, Jusczyk & Vigorito (1971). In this procedure, infants suck on a blind nipple connected to a pressure transducer whose output is converted to an electronic pulse. This signal is then used to measure the amplitude of sucking. With this method it is possible to determine whether infants are sensitive to a change in stimulation. A baseline period serves to assess the average sucking amplitude for each baby. Following the baseline, high amplitude sucks are "reinforced" by presentation of an auditory stimulus (say, a repeated spoken syllable or sequence of syllables). During this period, called habituation or pre-shift period, the baby usually increases the number of high-amplitude sucks per minute. However, after some time, most babies tend to decrease their sucking rate. This decrease provides a potential criteron to end the habituation period and switch into the test or postshift phase. Babies in the experimental and control

groups receive the same treatment until they reach this criterion. Thereafter, while the babies in the experimental group are reinforced by a different stimulus than the one used in the preshift phase, the babies in the control group continue to be reinforced by the same stimulus during the habituation and the test phase. If the sucking rate of the infants in the experimental group differs significantly from that of the control group during the test phase, we say that the experimental group has discriminated the change in the reinforcement Other wise one must conclude that the babies are not sensitive to the change or that the method is not sufficiently sensitive to detect a putative discrimination. Another procedure which is also used with young infants is the non-contingent-sucking procedure. This is a similar procedure except that the sucking behavior of the infant is exclusively used to assess the baby's activation and it does not have any other effect, e.g., on the nature or rate of reinforcement

With these and other methods it has been possible to establish that four-day-old infants have a number of dispositions that make them, all other things being equal, already set to acquire language. For instance, at this early age infants discriminate syllables that differ minimally from each other, Bertoncini, Morais, Bijeljac-Babic, McAdams, Peretz & Mehler, (1989). Furthermore, when two different syllables are presented, one to each ear, a stronger reaction is observed after a right-ear change than after a left-ear change. This result cannot be attributed to a permanent focalized attention to the right ear, since a different result can be observed when the infants are tested with non-linguistic acoustic stimuli. In fact, a significant interaction between side and material was observed. Syllables are reacted to more when they change in the right ear; but musical notes played by different instruments are reacted to more when they change in the left ear. This result suggests that infants are endowed with the facility to process speech sounds in a specialized manner - just as we know adults do. The left-hemisphere superiority for linguistic stimuli which adult listeners display is not acquired • it is part of the innate equipment of normal members of the species.

Bertoncini & Mehler (1981) showed that very young babies can process speech in terms of syllabically based procedures. Infants reacted to phonetic changes when these took place in syllabic environments, but they neglected similar changes in non-syllabic environments. Thus a C1VC2 (PAT) is discriminated from a C2VC1 (TAP), but a ClCxC2 (PST) and a C2VxCl (TSP) are not discriminated. To explain this pattern of results we can advance the hypothesis that the syllable is available as a basic representation of speech even during early infancy.

Further evidence for this arises from an experiment by Bijeljac-Babic, Bertoncini & Mehler (in preparation). They showed that when infants are habituated with many different CVCVs as reinforcements, they will dishabituate significantly

when they receive as post-shift stimuli many different CVCVCVs. Likewise, if the infants are habituated to CVCVCVs and tested with CVCVs they will again show a significant increment in post-shift sucking. Of course, a result like this remains difficult to evaluate since the average duration for the bisyllabic items is significantly shorter from that of the trisyllabic ones. Therefore it is conceivable that the infants react to the difference in average duration rather than to the number of syllables. To control for this potential artifact, the bisyllabic items were electronically expanded and the trisyllabic ones compressed (with no consequent change in the timbre, pitch, or spectral composition of the signal; this was achieved via an algorithm developed by CNET, Lannion, and modified at the Laboratoire de Sciences Cognitives). As a result of this manipulation the words in each list overlapped in duration. With these stimuli, infants also discriminate a change from bi- to tri-syllabic items or vice-versa. This result is clearly compatible with a syllabic interpretation.

However, although the lists differ in the number of syllables of the items, they also differ by the number of phonemes. Thus control experiments are currently being undertaken to evaluate whether infants can also distinguish two lists of bisyllabic items when the items in one are four phonemes long items while the items in the other list are six phonemes long. A syllabic parsing hypothesis predicts that infants will not discriminate these lists; a phoneme parsinghypothesis predicts that they will. Results from other laboratories suggest that phoneme discrimination is difficult. Bertoncini, Bijeljac-Babic, Jucszyk, Kennedy & Mehler (1988) showed that four-day old infants fail to notice the addition of a novel syllable to a set of four familiar ones used during the habi tuation phase unless the added syllable differs from each one of them by at least the vowel. This suggests that at four days of age infants pay little attention to phonemes others than vowels. So far, however, it must be acknowledged that the data are compatible with the view that in the initial state both the syllable and the phoneme my be viable perceptual units for the recognition of continuous speech.

Before we return to the issue of syllabic versus phonemic representations, we end this section by describing some further experiments on language recognition by very young infants. Every parent, nurse and caretaker knows that the infant is born into a noisy environment where speech signals appear simultaneously with all other kinds of noises. How does the infant select out of the auditory confusion those stimuli that are useful to capture linguistic structures? The answer is that the infant seems to come equipped with precocious procedures that enable it to characterize utterances as belonging to the maternal language or not This conclusion arises from studies conducted by Mehler, Jusczyk, Lambertz, Halsted, Bertoncini, & Amiel-Tison (1988) in which neonates and older infants discriminated

speech signals in different languages (spoken by the same speaker, a flawless bilingual). One of the experiments reported in the above mentioned study non-contingent sucking was used with four-day old infants born in Prance; the French infants reacted differentially to French, the familiar language, versus Russian, the foreign language. These same infants failed to make a differential response to utterances in English and Italian. Another experiment of the study used visual habituation with two month old infants born in the USA. The US born infants made a differential response to the English, the native language, versus Italian, the foreign language. However, these US-born infants failed to respond differentially to the Russian and French utterances that had been used in the other experiment, suggesting that some familiarity with one of the languages is needed to observe a discriminative response. In another experiment Bahrick and Pickens (1988) observed a good discriminative response in five-month olds between English and Spanish utterances.

Currently, research in the first author's laboratory has failed to find reliable discriminative responses to English versus French utterances. It is difficult at this time to know whether such a failure is due to incidental factors or to the closeness of French and English from a phonotactic point of view. But the findings with the other languages are clearly robust and important We hypothesise that the infant has used the prosodic properties of the maternal language to establish a very early category of familiarity, as a result of which previously unheard utterances in that language can be classed as familiar, while utterances pronounced by the same speaker in a unfamiliar language will fail to be assigned to the same category. Very shortly after birth, therefore, newborn infants can identify invariant properties in the signal. The argument that these invariants are prosodic is buttressed by the finding that a differential response can still be observed when the infants hear low pass filtered utterances in French and Russian or in English and Italian; low pass filtering preserves prosody but removes segmental structure. In contrast, when the stimulus tape is played backwards, no differential response to a change in language has been reported. Thus prosodic and intonational cues seem to play an important role in allowing the child to recognize speech - which is exactly what would be expected given the importance of prosodic information for adults, as described above.

In the next section we relate the question of the range of available phonological structures for use in perceptual processing to issues of meta-linguistic awareness.

4. AWARENESS AND THE PHONOLOGY OF LANGUAGE.

Preliterate children find it easy to tap to each syllable in a speech stream, but

hard to tap out a sequence of phonemes, Liberman, Shankweiler, Fisher & Carter (1974). A series of studies by our colleagues in Brussels examined the basis of this finding, Morais, Cary, Alegria & Bertelson (1979). The question that Morais asked was whether the differential difficulty of syllables versus phonemes arose from developmental factors, or was due to the subjects'illiteracy. In order to answer the question, they tested adult Portuguese illiterates with tasks very similar to those previously used with small children. The illiterates, like the children, failed to respond reliably to consonants, although they had little if any difficulty when they had to respond to syllables. Ex-illiterates of similar age and socio-economic background as the illiterates had no trouble with either task. Morais (1990) concluded that the experimental evidence available today suggests that phonological awareness is a most important factor for literacy acquisition in an alphabetic system.

If a rather ill-defined notion of phonological awareness is to offer an adequate explanatory tool to account for the behavior of young children in phoneme and syllable detection tasks, however, one must establish what causes children to be more aware of, say, syllables than phonemes before learning an alphabetic system. It is necessary to propose an account of why some parts of speech can become the object of awareness without overt training, while others require considerable effort to attain a similar degree of availability.

The explanation offered by Morais, Bertelson, Cary & Alegria (1986) relies upon a hierarchy of phonological awareness determined by relative size. Briefly, larger units are more accessible than smaller ones. Thus the intentional extraction of syllables from speech requires relatively little analytic effort, while the intentional extraction of phonetic and phonemic segments requires more effort, because, Morais et al. argue, the order of conscious recovery goes from the largest structures to the smallest ones. This in turn is the case because the larger structures are less embedded, and therefore require less analytic work than do the smaller ones.

In a sense, however, this is not so much an explanation as a paraphrase of the phenomenon. In order to account for awareness it might be more interesting to try and elaborate a speech processing model, preferably a model that can be computationally implemented, designed to bridge the passage from the initial to the steady state and to account for the development both of adult processing procedures and adult metalinguistic awareness. A tentative proposal for such a model was presented by Mehler, Dupoux & Segui (1990) under the name of SARAH (Syllable Acquisition, Representation and Access Hypothesis). Sarah proposes a structural coarse-grained linguistic unit of processing. It identifies a syllable-like prelexicai segment that is used to construct potential lexical entries at the *Initial*

State **and mediate lexical access and phonemic extraction and awareness at the** ***Stable State.*** **Lexical items are then accessed through a bank of syllabic analyzers (or some such molar unit suited to the phonolgy of the language). The first unit of an item contitutes the access code, i.e., the minimal amount of information that can activate a cohort of word candidates.**

CONCLUSION

The work which we have so sketchily described is, we believe, only the beginning of a rapidly growing tradition. The European setting lends itself ideally to the investigation of the effects of phonological diversity among languages; it is no surprise that it is in Europe that cross-linguistic investigations have uncovered the links between phonological structure andbasicprocessingprocedures. Likewise, bilingualism is easily studied in the European context; and it is in this context that the constraints which phonological structure imposes upon bilingual processing have been isolated. Finally, the proximity of phonologically diverse languages stimulates interest in questions of universality, and in the relation of metalinguistic awareness to linguistic processing; it is therefore again no surprise to find an active tradition of investigation of the characteristics of the initial state, and the determinants and effects of phonological awareness. As we have repeatedly remarked, the research so far has raised as many questions as it has answered, and a very large amount of ongoing research is currently addressing many of these questions. But this research is, we are sure, merely a pale shadow of what is yet to come. Phonological diversity among languages is one of the psycholinguist's richest sources of inspiration; European psycholinguists are bound to be inspired!

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