DOCUMENT RESUME

ED 335 895 FL 019 348

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TITLE The Sonority Cycle in the Acquisition of Phonology.
PUB DATE Apr 89
NOTE 10p.; In: Papers and Reports on Child Language Development, Number 28, p131-139, Aug 1989. For the proceedings, see FL 019 336.
PUB TYPE Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Child Language; Contrastive Linguistics; *Language Acquisition; Language Research; *Language Universals; Linguistic Theory; Longitudinal Studies; *Phonology; *Syllables
IDENTIFIERS *Sonority Cycle

ABSTRACT

This examination focuses on the idea that child language acquisition is constrained by the same principles that have been found to hold on syllable structure across languages. First, a recently-proposed constraint on syllable structure, the Sonority Cycle, is outlined, and the way that it accounts for syllabic structure across languages is described. Second, it is shown how the Sonority Cycle makes several predictions for child language acquisition when viewed as a principle of universal grammar. Third, data from the literature and from a longitudinal study that bear out the predictions are presented. Focus is on the predominance of consonant-vowel syllables in babbling and early meaningful speech, the imbalance of inventories of syllable-initial consonants as contrasted with syllable-final consonants, and several processes in child speech that have the effect of repairing certain syllable types defined as non-optimal by the Sonority Cycle. It is concluded that the hypothesis that the Sonority Cycle acts as a constraint on the mental representation of syllable structure provides a unified explanation of these data. (MSE)

THE SONORITY CYCLE IN THE ACQUISITION OF PHONOLOGY

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0. Introduction

It is well-known that children use syllable structure as a unit of organization from the earliest stages of language development. In this paper we show that the development of syllables over time follows a constraint which has been observed to hold on syllable structure cross-linguistically. We suggest that this can more generally be viewed as the result of a constraint on the mental representation of language, i.e. a principle of Universal Grammar, as proposed by Chomsky (e.g. 1986). In section 1., we introduce a recently proposed Constraint on Syllable Structure, namely the Sonority Cycle (Clements to appear, henceforth SC) and illustrate how it accounts for syllabic structure across languages. In section 2. we show how the SC makes several predictions for child language acquisition, when viewed as a principle of Universal Grammar. In section 3. we present some data from the literature as well as from an ongoing longitudinal study to suggest that the predictions for acquisition are borne out, thus providing preliminary support for the postulation of the Sonority Cycle as a constraint on the mental representation of language.

1. The Theory: The Sonority Cycle

In phonological theory, sonority, defined as a scalar feature distinguishing various classes of segments, was conceived primarily to explain preferred patterns of syllable structure that have been observed cross-linguistically. The Sonority Sequencing Principle, originally found in the work of Sievers (1881) and Jespersen (1904), states that within the syllable, segments should increase in sonority as one proceeds from the margins to the peak. The constraint we consider in this paper is a reformulation of the Sonority Sequencing Principle, namely the Sonority Cycle proposed recently in Clements 1988. It states that the preferred syllable type rises sharply in sonority at the beginning, but drops gradually toward the end giving the pattern illustrated in 1.

1. The Sonority Cycle (Clements 1988)
"...the sonority profile of the preferred syllable type rises sharply at the beginning and drops slowly toward the end."

In this section we give a brief overview of the definitions and principles underlying the Sonority Cycle. Clements proposes that the sonority rank for each class of segments be derived from a set of binary features and measured in terms of the sum of the [+] specifications for each feature. He thus arrives at the classification in 2. whereby obstruents rank lower in sonority than nasals, nasals rank lower then liquids, liquids rank lower than glides and glides rank lower than vowels.

2. Major Class Features in the Definition of Sonority (Clements 1988)

O <	N <	L <	G <	V	
-	-	-	-	+	syllabic
-	-	-	+	+	vocoid
-	-	+	+	+	approximant
-	+	+	+	+	sonorant
0	1	2	3	4	rank (relative sonority)

O = obstruents, N = nasals, L = liquids, G = Glides, V = Vowels

1.1. The demisyllable

In Clements' proposal, the basic unit for which sonority is measured is not the syllable itself, but the demi-syllable, i.e. initial and final demisyllables as defined in 3. below. Here, the syllable is divided into two overlapping parts, sharing the nucleus.

3. " A demisyllable is a maximal sequence of tautosyllabic segments of the form $C_m ... C_n V$ or $VC_m ... C_n$, where $n > m > 0$."

Thus, in the closed syllable *mat*, the initial demisyllable consists of the sequence *ma* while the final demisyllable is formed by the sequence *at*. Using the demisyllable as opposed to the syllable allows for a differentiation in the definition of optimality for onsets on the one hand and codas on the other, a phenomenon that has been attested cross-linguistically (cf. Greenberg 1978). Each demisyllable type is assigned a value D, measured in terms of the dispersion in sonority within it as seen in 4.

4. D values for Initial and Final Demisyllable Types

ID	FD		D
OV	VO	=	0.6
NV	VN	=	.11
LV	VL	=	.25
GV	VG	=	1.00

The difference in optimality between initial and final demisyllables is formalized in the Dispersion Principle which states that the preferred initial demisyllable minimizes D, while the preferred final demisyllable maximizes D. Demisyllable types can now be ranked for optimality or conversely, for complexity, in terms of their sonority profiles, resulting in the ranking illustrated in 5.

5. Complexity Rankings for Initial and Final Demisyllable Types

ID	C	FD	C
OV	1	VG	1
NV	2	VL	2
LV	3	VN	3
GV	4	VO	4

ID = Initial Demisyllable
FD = Final Demisyllable
C = Complexity

Here, the numbers indicate relative complexity, with the lowest number being the least complex (hence optimal) demisyllable type. The complexity measure is extended to one-member demisyllables (i.e. consisting of one segment only): an initial demisyllable consisting of a vowel (e.g. in the syllable *am*, the initial demisyllable is the vowel *a*) is assigned the complexity measure 5; a final demisyllable consisting of a vowel (e.g. in the syllable *ma* the final demisyllable is *a*) is assigned 0.

1.2. Cross-linguistic Preferences

Several cross-linguistically observed phenomena can now be accounted for directly by the Sonority Cycle. In this paper we will focus on three:

i. The CV syllable is the least complex, hence "unmarked" syllable type.
If the complexity measure of a syllable is defined as the sum of the complexity measures of its initial demisyllable and its final demisyllable, it becomes possible to rank syllable types by the Sonority Cycle. In particular, the SC predicts that any syllable with an onset and without a coda, for example *pa* , has a lower complexity measure than any syllable without an onset and with a coda, for example *ap*. This can be seen by comparing the complexity scores in 5. above, for the most complex open syllable type to that for the least complex closed syllable type (see 6.)

6. The complexity measure for any given syllable is the sum of the complexity measures of its id and its fd.

The most complex CV is less complex than the least complex VC :
most complex CV : GV = GV (4) + V (1) = 5
least complex VC : VG = V (5) + VG (1) = 6

Thus, the Sonority Cycle predicts the CV syllable to be the least complex syllable type.

ii. The Sonority Cycle accounts directly for what has been termed the Maximal Onset Principle. This principle requires that the sequence VCV be syllabified as V.CV, rather than VC.V This can again be seen by a comparison of rankings for initial demisyllables and final demisyllables in 5.

iii. The Sonority Cycle accounts for the Syllable Contact Law (Hooper 1972, Murray and Venneman 1983), which states that the preferred contact between two consecutive syllables is one in which the end of the first syllable is higher in sonority than the beginning of the second, thus showing a decline in sonority transsyllabically.

2. The SC as a Principle of Universal Grammar

As mentioned above, sonority was conceived primarily to explain preferred syllable types cross-linguistically. What is the relevance of the Sonority Cycle to acquisition? Clements proposes the Sonority Cycle as a universal (rather than a language-specific) principle, and imputes it to the implicit (rather than "conscious") knowledge of speakers. It can thus be conceived of as a principle of Universal Grammar in the sense of Chomsky (e.g. 1986). UG principles have in recent linguistic theory been defined as constraints on the mental representation of linguistic units. Extending this definition to the Sonority Cycle, it could be viewed as an initial constraint on possible syllable structure. This constraint would then subsequently be relaxed as the child is presented with exmaples violating it, that is, by the presentation of positive evidence that the language allows syllable types which diverge from the optimal type as specified by the Sonority Cycle. Under this view, the SC makes several verifiable empirical prediction for language acquisition. Extending the generalizations stated in i - iii above to acquisition it is predicted that phonological development should be guided by the following principles:

(a) CV syllables should appear before VC syllables
(b) a VCV sequence will be syllabified as V. CV rather than VC. V
(c) the preferred contact between two consecutive syllables is one where the end of the first syllable is higher in sonority than the beginning of the second.

3. The Data

In this section we will present some data supporting the above predictions.

3.1. Primacy of the CV syllable

The first prediction can be translated to state that the CV syllable is the unmarked one, i.e. the one the child will start with, since it represents the optimal syllable type as defined by the Sonority Cycle. The literature on child phonology widely attests a marked preference for CV syllables which extends from the babbling period through early meaningful speech, to later stages in acquisition when language-specific rule learning is well in progress (4-5 yrs). This preference has been noted in cross-sectional as well as longitudinal studies, in experimental studies observing larger groups of children (Winitz and Irwin 1959, Stoel-Gammon 1985, Ingram 1974) and in the classical diary studies of single children (cf. Leopold 1947, Velten 1943, Smith 1982 etc.). Furthermore, it has been observed in children of many different language backgrounds (cf. Locke 1983, Jakobson 1968), and, somewhat surprisingly, in the babbling of deaf children (cf. Syken 1940).

3.1.1. CV in the Babbling Stage

It is of some interest that the late babbling period, i.e. the period of vocalization in the month (or so) prior to the onset of meaningful speech should be marked by CV syllables. This has often been taken as evidence that Jakobson's fundamental distinction between babbling and early speech was basically incorrect (cf. de Villiers and de Villiers 1974, Menn 1982, etc.) The babbling period is described by Jakobson as containing "an astonishing quantity and diversity of sound productions." He cites Grégoire's (1937) observation that at the height of the babbling period the child "is capable of producing all conceivable sound". The onset of meaningful speech, by contrast, is characterized according to Jakobson by a drastic reduction in the sounds produced.[1] He attributes this to the child's emerging system of phonemic oppositions.

The claim of unconstrained babbling has since been challenged by many researchers (cf. Oller et al. 1976), who found that while infants do produce segments which are absent from the language of their particular linguistic community, such segments occur only occasionally. Preference seems instead to be given to those segments which also predominate early meaningful speech, i.e. stops and nasals. This has led most researchers to postulate a continuous transition from babbling to early speech rather than the abrupt qualitative change from chaotic sound production to structured vocalization hypothesized by Jakobson. This continuity seems to hold for syllable structure as well: For example,

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[1] It should be mentioned that Jakobson seemed to restrict his observations to the production of segments rather than to syllable type.

Locke (1983) writes that the preference for CV syllables is "one of the more compelling patterns" in the babbling of infants as well as in early speech. Stoel-Gammon and Cooper (1985) report that in late babbling, CV syllables occur much more frequently than single V's or CVC syllables. This fact has also been pointed out by Cruttenden (1970).

3.1.2. CV Syllables in Early Meaningful Speech

The evidence for the predominance of CV syllables in early child language is equally well-attested. Surveys of phonological processes in language acquisition (like Macken and Ferguson 1982, de Villiers and de Villiers 1974), etc. invariably point out this fact. To cite an example, Locke (1983) reports that in the 50 word vocalization of a Czech child, 92.8% of the items were CV syllables.

The child's preference for CV syllables is attested by two phenomena: predominance of CV in spontaneous early utterances, and the structure changing processes which conform (adult) non-CV forms to CV patterns. The most commonly-cited processes in the literature in this regard are cluster reduction, final consonant deletion and reduplication, all characteristic of early child language cross-linguistically. Some examples from the literature are given below.

7. (a) Final consonant deletion:

English:
bird --> bo (Ingram 1974)
dog --> da (de Villiers and de Villiers 1974)
goose --> gu (Branigan 1976)
hi --> ha (Branigan 1976)
bath --> ba (Locke 1983)

French:
place --> fa (Lewis 1936)
Slovenian:
bombon --> bo (Kolaric 1959)

(b) Cluster-reduction by V-epenthesis:

English:
e.g. blue --> belu (Locke 1983)

(c) Cluster reduction by C deletion:

French:
pied /pje/ --> pe (Lewis 1936)

English:
tree --> di (Smith 1982)
taxi --> gegi (Smith 1982)

Slovenian:
mleko --> meko (Locke 1983)

(d) Reduplication of V in CVC forms:

English (Ross 1937):
back --> baga
beach --> bihi
dog --> dogo

Each of these processes changes some adult sequence into a CV pattern. Under the hypothesis we are considering, the preference for CV syllables would be the result of an initial constraint on the mental representation of the syllable as defined by the Sonority Cycle. Support for our hypothesis would be found if it could be shown that this preference is not somehow due to input, or to a constraint on articulation. While obviously such evidence is hard to find, there are some studies which suggest that our hypothesis is correct. Thus, in an early study of deaf children, Syken (1940) determined that CV syllables predominate the babbling of deaf 3-4 year-old children. This would argue against the hypothesis that CV syllables are preferred due to input (i.e. their predominance in the speech of caretakers). Some support also comes from experiments on the perception of speech categories by young infants (2-6 months) which suggest that there is sensitivity to CV syllables even at that early a stage (cf. Eimas 1984, Kuhl 1980, Miller and Eimas 1980). While this is only suggestive, such studies indicate that sensitivity to the CV syllable is to a certain degree independent of articulatory considerations, and would thus be consistent with the hypothesis that proclivity to certain syllable types is the result of a constraint on mental representation.

3.1.3. Beyond CV Syllables

Another fact which coheres with the prediction that the CV template constrains phonemic acquisition is the imbalance in the inventory of consonants in initial and final position, even after children produce CVC syllables freely. This has been noted by Stoel-Gammon 1985, Ingram 1981, Shibamoto and Olmsted 1974, Winitz and Irwin 1959, Branigan 1976). A typical example from the acquisition of English is the following: During a stage where a child has voiced and voiceless stops, several nasals as well as glides in initial position, s/he will typically only have voiceless stops and perhaps one nasal in final position. Stoel-Gammon (1985) statistically calculated consonant frequency in the two syllable positions and reports that for labials and alveolars (i.e. [+anterior]), the difference in use in initial versus final position is significant at $p < .002$. Similar data have been reported for the acquisition of Puerto-Rican Spanish. Anderson and Smith (1987) measured the occurrence of consonants in relative syllable positions in the speech of 2-year-olds, and found that 56% were produced in "syllable-releasing" position (i.e. initial demisyllable, e.g. karloh), whereas only 14% appeared in "syllable-arresting" position (i.e. final demisyllable, e.g. aßril), with 30% in what they termed "ambisyllabic" position. The example they give for this position is the /l/ in bola, and might thus in fact have been syllable-initial as well. These results may have been in part caused by the fact that Spanish has predominantly open syllables. However, they report that the children also omitted target consonants in final demisyllables more frequently than target consonants in initial demisyllables. Furthermore, while stops, fricatives, and nasals appeared freely in initial demisyllables, the majority of consonants produced in final demisyllables (52%) consisted of /h/ and /ʔ/. They also report a lower rate of accuracy in the production of consonants in fd's than in id's. Overall, then, the Spanish data are consistent with the English data, attesting to a higher occurrence of consonants in initial demisyllable position and greater difficulty with consonants in final position. This phenomenon can be explained under the view that CV but not VC is ranked optimal by the Sonority Cycle.

3.2. The Maximal Onset Principle

We will now turn to some data supporting the Sonority Cycle as manifested by the Maximal Onset Principle. The data are from Stemberger (1988) who noted the following processes in the speech of his child Gwendolyn.

3.2.1. Word-final resyllabification:

G went through a stage where V-initial utterances were obligatorily preceded by an inserted glottal stop. When this became optional, there was a tendency for final consonants to be resyllabified with the following word if it began with a V.

8. ...find us --> [fai.nʌs]
   ...look at --> [je.tat]
   ...arm is [au.mi:]

3.2.2. H-fusion:

From the age of 2;6.8 to 2;9.19 G resyllabified final voiceless stops with the following syllable if it began with /h/, e.g.

9. ... about him --> [ba.tʰim]
   ...right here --> [wai.tʰi]
   ...want hold --> [wa. tʰa:..]

3.2.3. Liaison:

G normally deleted word-final /d,z, nd, nz/. However, when the following word began in a vowel, she would pronounce them, resyllabified to id position.

10. ..head over --> [ha:. dou...]
    ...untied it --> [ʔʌn. tʰai. dit]
    ...stand up --> [tʰi:. nʌp]

In all the above, the strategy is to 'repair' initial demisyllables of the last optimal shape, i.e. GV or V (rank 4 and 5) by maximizing the onset with the addition of an obstruent or nasal, resulting in id's of rank 1 and 2. If this strategy turns out to be a common one in child speech, this would provide strong evidence for a constraint on the shape of id's, as specified by the Sonority Cycle.

3.3. The Syllable Contact Law.

In this section we present some data from Jenny, a child who participated in one of our ongoing longitudinal studies. Jenny was chosen because she did not have consonant clusters productively, and we were interested to find out if their ememrgence in her speech would in any way follow the predictions of the Sonority Cycle. Here we report only a small part of our findings, bearing evidence for what is predicted by the Sonority Cycle for transsyllabic consonant sequences.

When we started the study, Jenny had no initial clusters, reduced certain medial clusters and had consonant + /s/ clusters in word-final position. Of interest to us are her medial clusters: Jenny reduced all her VO.OV sequences to V.OV. Some examples are shown below.

11 a. Jenny, age 3.2, Medial Clusters:

VO.OV --> V.OV
toothpaste --> [tu.peɪt]
basket --> [bæ.tət]
footprints --> [fʊ.pɪns]
footsteps --> [fʊ.tɛps]
have to --> [hæ.tu]

11 b. VN.OV
blanket --> [bæn.tət]
envelope --> [ɛŋ.və.lot]
rainbow --> [reɪm.bo]
dancing shoes --> [dæn.sʌ ʃuz]
monster --> [mʌn.tə]

Obstruent deletion occurred both inside the word as well as across words, as can be seen from the last example in 11a. At the same time, Jenny allowed VN.OV sequences freely, as seen in 11 b. Note that the consonants which were deleted from the VO.OV sequences were otherwise present in her speech, thus barring the possibility that an overall production constraint may have been at work. For example, /k/, produced as a retroflex t (velar fronting) occurred in words like can, come, make, package, etc. /t/ in words like toothpaste, tea, cat, etc. /v/ in envelope. The fact that she allowed VN.OV sequences furthermore shows that it was not a simple constraint against two consonant clusters. Rather, Jenny seemed to restrict her transyllabic clusters to the more optimal type, as defined by the Sonority Cycle, i.e. declining in sonority.

4. Summary.

The data presented in this paper, taken from several studies on phonological development suggests that child language acquisition is constrained by the same principles which have been found to hold on syllable structure cross-linguistically. In particular, we have focused on the predominance of CV syllables in babbling and early meaningful speech, the imbalance of inventories of syllable-initial consonants as opposed to syllable-final consonants, and several processes in child speech which have the effect of repairing certain syllable types which are defined as non-optimal by the Sonority Cycle. We have suggested that the hypothesis of the Sonority Cycle as a constraint on the mental representation of syllable structure can provide a unified explanation of these data.

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