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THE ACQUISITION OF STOP CONSONANTS BY DANISH TWO-YEAR-OLD CHILDREN

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Abstract: This paper presents VOT data collected from four two-year-old Danish children. The results show that they differentiate the two categories - i.e. aspirated vs. unaspirated stops - in their production. The duration of aspiration in the unaspirated stops is found to be noticeably longer (the boundary between the two categories is at 50 ms) than what has been found in other investigations. An articulatory model accounting for the priority of a 0-30 ms VOT range for unaspirated stops is discussed and partly rejected.

1. Introduction

The phonological and phonetic aspects of children's acquisition of their mother tongue has attracted increasing interest, especially during the last decade. In spite of this, Danish remains almost unexplored in this field. To my knowledge, only three investigations of Danish child language have been published, viz. Jespersen (1916) which was intended to draw the attention of a wide public to linguistic phenomena, but is mainly of historical interest today, Abrahams (1955), introducing Roman Jakobson's ideas, containing a registration of the phonemes most often mispronounced by normal and impaired French, Danish and English children, and finally, Jørgensen (1971) which contains a registration of the development of selected subsets of the phonetic systems of the author's two children during their very first years of life (the material was collected 30 years earlier - a fact which has to some degree influenced the treatment).

The scarcity of phonetic investigations of Danish child language is regrettable, mainly because the Danish phonetic/phonological system contains several interesting phenomena (a presentation of the Danish phoneme system is given by Basbøll, 1969) among them:

1) Aspiration/voicing and the relation between these two features (Danish stops are distinguished only by aspiration, whereas one fricative-pair is distinguished by voicing).

2) A rich vowel system. Danish has at least 10 qualitatively different vowels which may all appear long and short.

3) Stød (the Danish stød may be considered a phonemic, suprasegmental entity).

The three phenomena are all of interest in relation to the theories concerning children's acquisition of language, among which the theory advanced by Jakobson (1942) is of fundamental importance, and there are few papers on child language that do not refer to this work.

This paper is only concerned with one of the problems pointed to above, viz. the relation between aspirated and unaspirated stops, and the investigation reported below is an attempt to answer the following question: How do Danish children at the age of approximately two years "treat" (phonemically and phonetically) the aspiration distinction in the stop consonants?

2. Other investigations

In any survey, however sketchy, of problems in first language acquisition it seems natural to quote Roman Jakobson. The following quotation may be representative of Jakobson's opinion about children's linguistic behaviour when learning a language with a distinction of aspiration in the stop consonants. Explicitly mentioning Danish, Jakobson (1942, p. 9f) says:

"Solange die Verschlusslaute beim Kinde nach dem Verhalten des Kehlkopfs ungespaltet bleiben, werden sie gewöhnlich stimmlos und ohne Aspiration vollbracht: das Kind verallgemeinert diese Spielart unabhängig davon, ob das landläufige Vorbild (wie z.B. die slavischen und romanischen Sprachen) neben ihr ein stimmhaftes unaspiriertes oder ein stimmloses aspiriertes Gegenstück enthält (wie es im Dänischen der Fall ist);" and later on the same view is repeated (p. 95): "... der Konsonant ist gewöhnlich stimmlos auf der Anfangsstufe der Kindersprache, auch bei der partiellen Lautstummheit verliert er seine Stimmhaftigkeit (...), und bei der partiellen Lauttaubheit werden eher die stimmlosen als die stimmhaften Konsonanten erkannt ...".

Thus, Jakobson does not say anything about the age at which the distinction is acquired nor about the relation between production and perception. What is in focus is the order in which phonemic contrasts are acquired. As a consequence of the phonemic view held by Jakobson, little attention is paid to the precise phonetic realisations. Most often data are given in phonemic interpretation rather than in phonetic transcription.

2.1 When is the unaspirated/aspirated distinction acquired?

Investigations of more recent date have paid special attention to the age at which the aspiration distinction is acquired. Investigating the perceptual acquisition of the "voicing" distinction (which for American English most often is an aspiration distinction), Garnica (1971) finds that this distinction is acquired very late by American children. It appears to be the latest among the 13 distinctions tested, and a closer inspection of the results reveals that not even the oldest subject (age 3;5 years) perceptually masters the voicing distinction. In several respects these results are surprising and in my opinion they seem rather suspicious. In particular, the results for the oldest subject are extraordinary: he only masters 2 out of the 9 distinctions tested for. He does not master the distinction d vs. z which is mastered by all (i.e. 4) the other younger subjects. All these subjects (age 1;9 - 2;10) except one (age 1;9) master more distinctions than does the oldest child. Another example of the surprising results is that one subject does not master the distinction b vs. zero, whereas she does have b vs. m. One possible explanation of the curious findings may lie in the method used. The subjects were asked to remember (for a short time) nonsense names given to toys. The ability to remember newly learned nonsense words is probably highly sensitive to factors such as attention and general interest.

Not surprisingly, other investigations have not confirmed Garnica's results concerning the age at which the distinction is acquired. Edwards (1974) finds that 8 out of 9 children (age 1;8 - 3;11) perceive correctly the t vs. d distinction and that 7 out of 9 have a correct production, too. Unfortunately, the precise ages of those with correct production are not given.

The Garnica results are also disconfirmed by an investigation by Wintercorn et al. (1967). In this investigation 5 children (aged around 3 years) were asked to repeat synthesized syllables with varying VOT values (from -30 to +100 ms). The results are summed up as follows:

(p. 43): "Four of the five subjects gave almost "errorless" repetitions of the test tape. They responded to practically all of the stimuli with VOT values of -30, -5 and +20 as /da/ and to almost all other stimuli as /ta/, just as adult subjects do. Furthermore, their repetitions were made immediately after stimulus presentation. None of these subjects made more than three errors and the errors were not systematically distributed. The errors which did occur were judged to be due to inattention."

The results of an investigation by Gilbert (1977) in which 6 children's production of d and t (spontaneous speech) was examined, are summed up by the investigator as follows (p. 7):
"In this investigation we have attempted to support the hypothesis that VOT has assumed adult values for /d/ and /t/ by an average age of 3;0. This attempt has proved partially successful in that the data for initial /d/ VOT values taken from SPONTANEOUS discourse do, for the most part, fall clearly within the adult range of VOT values reported by Lisker & Abramson (1964), with few intrusions into the adult long voicing lag category."

In conclusion, it seems safe to state that the general opinion is that around the age of 2 the child has gained complete control over the aspiration (voicing) distinction perceptually and between the age of 2 and 3 the distinction is also mastered in production.

3. Subjects - collection of the material

The main topic of the present investigation was the development of distinctive aspiration in stop consonants. Since - as has been pointed out by Jakobson (1942), among others - the stops are developed earlier than other members of the consonantal system, it was necessary to choose as subjects children who were very young, but nevertheless capable of producing stop consonants at at least two of the three places of articulation used in Danish

stops (bilabial, alveolar, and palato-velar). This stage of linguistic development is reached (it appeared) around the end of the second year. Children whose parents were not speakers of Advanced Standard Copenhagen Danish (see Basbøll, 1969) and children who suffered from disorders of speech or hearing or other physical or psychical impairments were excluded as subjects.

The subjects were selected among 32 children attending a day nursery in the centre of Copenhagen, and the selection was based on careful daily observation during several weeks. Seven children were chosen as potential subjects, but three of them had to be excluded since they could not cope with the unfamiliar experimental situation. The remaining 4 subjects were KR (boy) 2;1;2, MI (boy) 2;1;0, NO (boy) 1;11;1, and TI (girl) 1;10;0.

As it was considered desirable for the linguistic material to be so close to natural spontaneous speech as possible (rather than imitated speech) the recordings were made at the nursery, where the children were familiar with the environment.[1]

At the recording sessions which lasted from 20 to 30 minutes, the child and a staff member (always the staff member preferred by the child) were talking about that particular child's favourite toys or picture books. The experimenter handled the recording and asked additional questions if the situation permitted. The quality of the recordings was not always the best, but with young children it seems to be the only method which will ensure the desired naturalness and spontaneity.

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1) In the literature on child language the relationship between imitated and spontaneous speech is occasionally discussed (e.g. Templin 1947, Ingram 1976, Faircloth et al. 1970, Danielson et al. 1976, and Edwards 1974). The question is of primary importance when investigating children's active vocabulary. If the child succeeds better when imitating, no true picture of the linguistic system normally used by the child is achieved if imitation is used in the test, and consequently the imitation method must be rejected. The general opinion seems, however, to be that imitation is safe enough as a method. The investigations of the relation between the two methods have some weaknesses, however: (1) none of the investigations involved normal young children (two years or younger), (2) at least one of them states that imitation causes improvement of the speech, (3) it seems counterintuitive that young children should not perform better in imitation (how do they learn new pronounciations if not by imitating?). Accordingly, I chose the safest method - spontaneous speech.

Collecting material in the form of spontaneous speech from very young children has one serious disadvantage, however, in that it is extremely laborious and time consuming to get a representative corpus (even only partly so).

Altogether about four hours of speech were recorded, corresponding to approximately 500 phrases of one or (frequently) more words. The number of phrases recorded for each child varied between 80 and 130. As a rough estimate, the words in the recordings represent about 50 per cent of the children's active vocabulary. The subset of the material to be analyzed here was 270 occurrences of stop consonants in word initial position.[1]

The duration of aspiration (VOT) in these stops was measured from wide-band spectrograms with expanded frequency scale (200 - 4000 Hz). The duration was measured from the beginning of the explosion phase to the beginning of the voice bar in the following vowel.[2] 255 measurements of aspiration were obtained, 15 items being left out for various reasons.

4. Results

The distribution of VOT values measured in the supposedly aspirated and unaspirated stops (i.e. aspirated/unaspirated in the adult language) are displayed graphically in figs. 1 and 2.

The data indicate that the children in their speech production seem to be able to differentiate the two categories with reasonable certainty. A one-tailed Mann-Whitney U-test showed that the VOT values of ptk were significantly longer than those of bdg at the 5% level or better in all cases but one (see table 1).

Notice, that although a visual inspection of MI's distribution of /t/ and /d/ might lead to the conclusion that the two categories are not separated, the statistical test proves that in fact they are. A closer inspection reveals that with a boundary at +70 ms the overlapping is actually quite small - viz. 4 occurrences of /t/ below this value and 2 occurrences of /d/ above it.

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1) Apart from the measurements of aspiration in the stop consonants, a phonetic transcription was made of the entire material, the purpose of which was to provide the basis for a more general evaluation of the material in relation to Jakobson's theories of the linguistic development in children. Some aspects of this work are briefly reported in Jørgensen (1978).

2) This will yield systematically lower values than if the onset of periodic energy in the higher formants are used as a criterion.

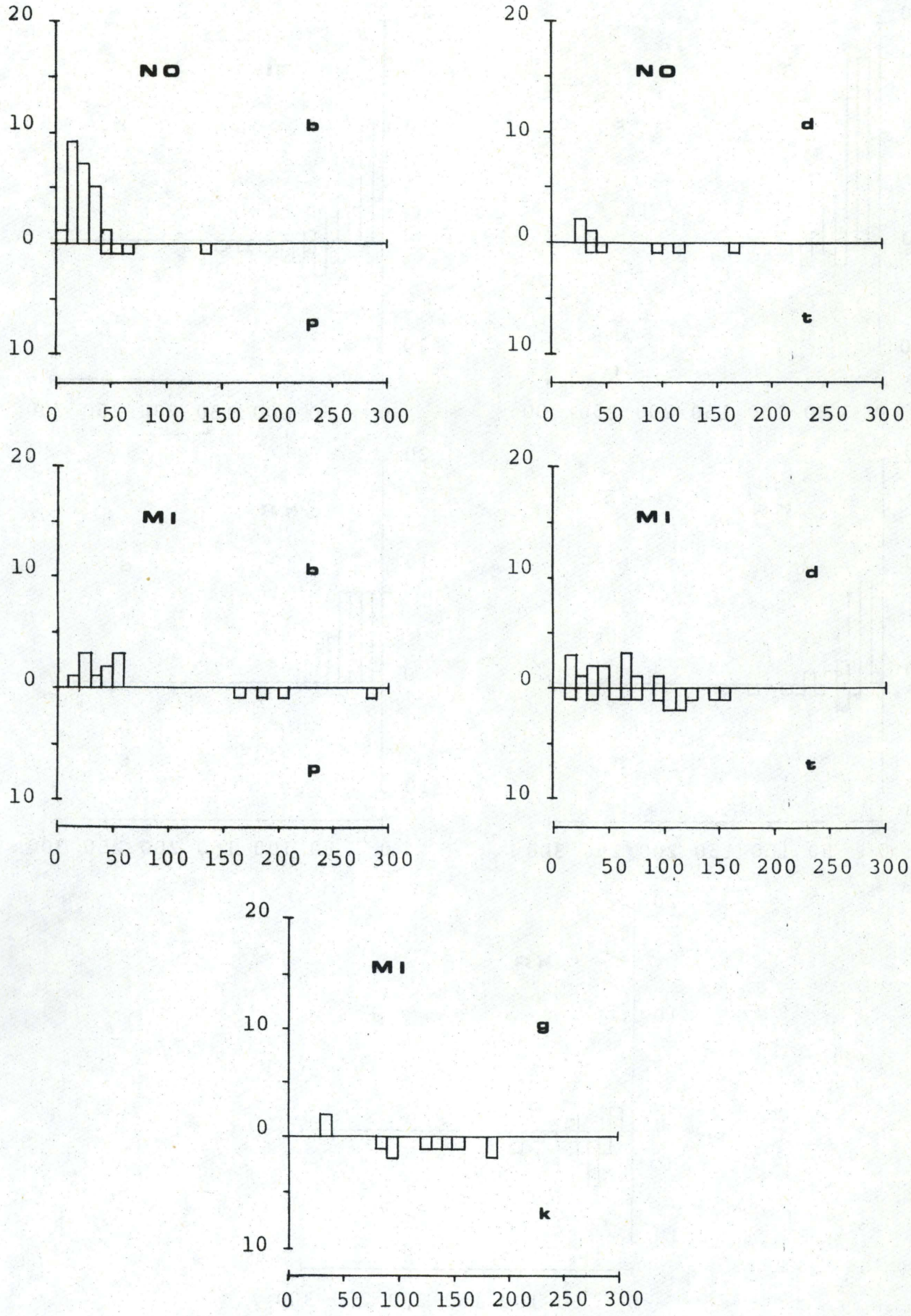

Figure 1

Histograms showing number of occurrences (vertical axis) vs. duration of the aspiration (horizontal axis). Subjects NO and MI.

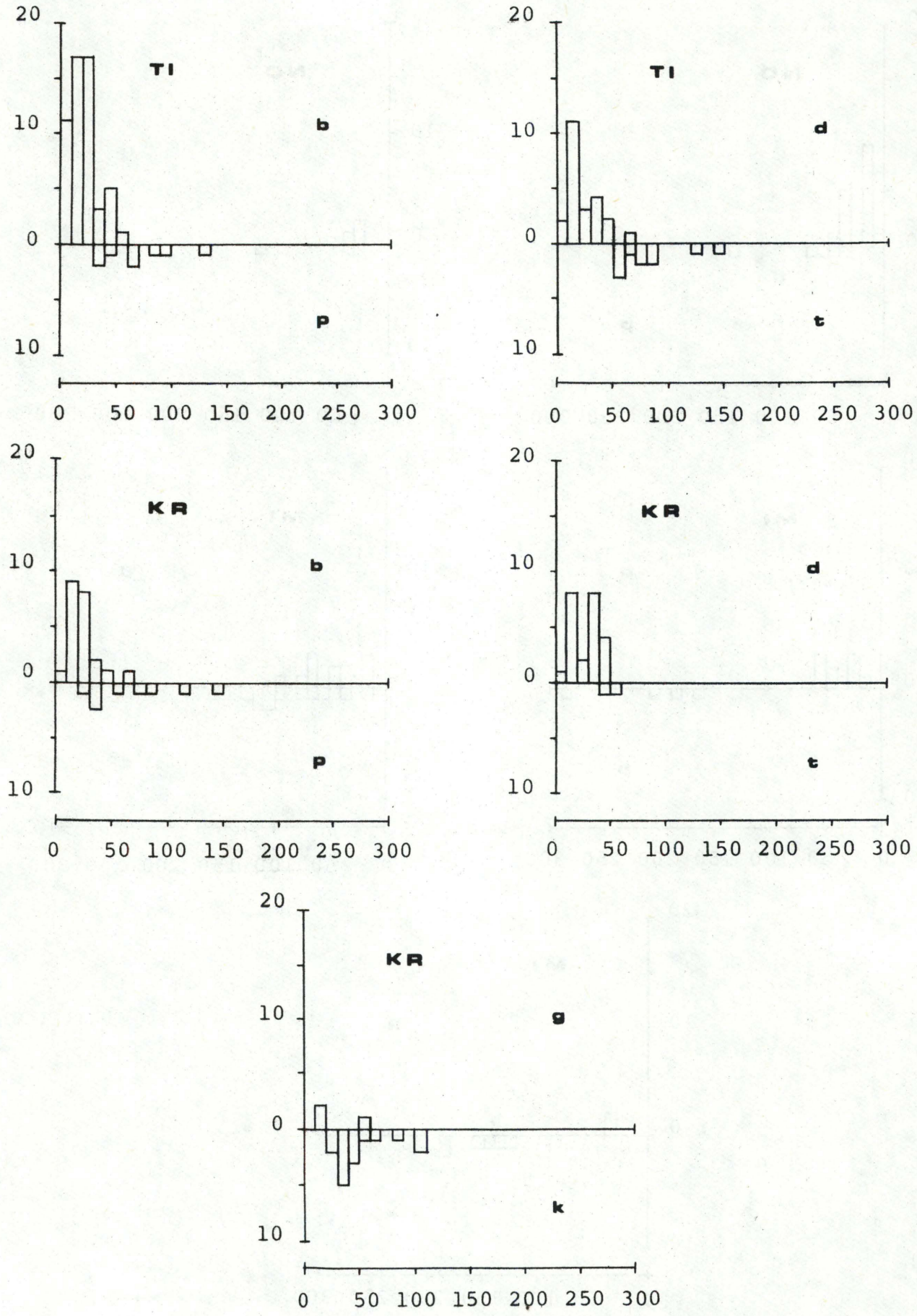

Figure 2

Histograms showing number of occurrences (vertical axis) vs. duration of the aspiration (horizontal axis). Subjects TI and KR.

Table 1

Levels of significance obtained in one-tailed Mann-Whitney U-tests of the hypothesis ptk>bdg with respect to voice onset time.

	p - b	t - d	k - g
TI	p<0.01	p<0.001	
KR	p<0.01	p<0.001	p>0.05
NO	p<0.001	p<0.05	
MI	p<0.001	p<0.01	p<0.001

Table 2

Tables showing the distribution of the measured VOT values relative to four different boundaries (30 ms, 40 ms, 50 ms, 60 ms).The terms "aspirated"/"unaspirated" in the tables mean +/- aspiration in the adult language in the words measured.

		VOT< +30 ms	VOT> +30 ms
"aspirated"	p	1	24
	t	1	29
	k	2	22
"unaspirated"	b	84	25
	d	33	29
	g	2	3

		VOT< +40 ms	VOT> +40 ms
"aspirated"	p	6	19
	t	3	27
	k	7	17
"unaspirated"	b	95	14
	d	48	14
	g	4	1

		VOT< +50 ms	VOT> +50 ms
"aspirated"	p	8	17
	t	5	25
	k	10	14
"unaspirated"	b	108	1
	d	56	6
	g	5	0

		VOT< +60 ms	VOT> +60 ms
"aspirated"	p	10	15
	t	10	20
	k	11	13
"unaspirated"	b	108	1
	d	56	6
	g	5	0

In connection with the results, the following points should be noted: Repetitions of a word have been treated as if they were new words, since most often repetitions occurred not because a word was repeated in a parrot like way but simply because the word was an important part of that child's vocabulary and consequently frequently used.

Clusters consisting of s + stop consonant often reduced to single stops. These stops have been treated as unaspirated stops.[1] The reason for doing so is partly that these stops are phonetically unaspirated in the adult language and partly that the children, not surprisingly, treated them like normal, unaspirated stops.

It should also be noted that e.g. TI at the time of recording had no velar stops in her speech, but substituted an alveolar stop for the velar one. These substitutions have been included in the alveolar stop category.

5. Discussion

The results indicate that Danish children at the age of two years, except for very few mistakes, keep aspirated and unaspirated stops apart in spontaneous speech.

In conformity with what has been found in other investigations, e.g. Kewley-Port et al. (1974), the present results seem to show that the marked members of the pairs (for Danish, the aspirated stops) are spread over a wider range in terms of VOT than the unaspirated stops.

At one point, however, there is a noticeable difference between the results of this study and those of others: the duration of the aspiration in the unmarked (unaspirated) stops is remarkably long compared to what has been found by other researchers.

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1) The phonemic interpretation of the stop consonant (with regard to the voicing/aspiration feature) of /s/ + stop consonant is in Danish complicated by the existence of both /sf/ (found in a few words) and /sv/.

This is shown in table 2 from which it appears that the best separation of the VOT measurements into the aspirated and unaspirated categories is achieved when the boundary between the categories is placed at +50 ms VOT. At values lower than that (viz. +30 and +40 ms) and higher (+60 ms), the separation is poorer.[1] This is in disagreement with Port and Preston (1974), who state (p.198) that: "It is evident that the children's distributions are remarkably similar to one another. Each has a single mode, and the majority of the productions fall in the 0 to +20 ms voicing lag region." and with Preston et al. (1967), who in an investigation of prelinguistic Lebanese and American children summed up their results (p. 120) as follows: "With respect to apical stops for which the most data is available, these children show uni-modal distributions falling mainly in the 0 to 20 msec voicing lag range. This occurs in spite of the fact that the Lebanese children had been exposed to apical stops with voicing lag between 40 and 100 msec or greater."

The present data are also in disagreement with Lisker's (1970) assumption of the priority of the 0 - +30 ms VOT range.[2] Lisker's view is based on data from a cross-language investigation, Lisker et al. (1964), showing that all of the languages investigated possessing a VOT distinction among the stops are characterized by the following structure: short voicing lag plus either voicing lead or long voicing lag, the point being that the short voicing lag is never missing. The view that the short voicing lag range is the preferred one, gives support to the ideas advanced by Jakobson, and, naturally, the wish to find an articulatory explanation for this preference was strongly encouraged by the work of Lisker et al.

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1) Setting the boundary at +50 ms also has the advantage that most of the deviant productions are found to be in the natural direction: marked (i.e. aspirated) stops are wrongly pronounced as unmarked (i.e. unaspirated) stops. A boundary at +30 ms implies that the mistakes would be going in the opposite, <u>un</u>natural direction, i.e. from unmarked to marked.

2) This range may even be reduced to a 0 - +25 ms VOT range, according to the data presented in Lisker et al. (1964) and illustrated by the following quotation (p. 403): "...for it appears that the stop categories overall fall generally into three ranges: one from about -125 to -75 msec, one from zero to +25 msec, and a third from about +60 to +100 msec. The median values for these ranges are -100, +10 and +75 msec respectively."

The systematically longer aspiration found in my material gives rise to questions of some theoretical interest. Is it true that the VOT range 0 - +30 ms is the universally unmarked one? At what age does the influence of the adult linguistic system on that of the child make itself felt? Narrowing the scope to the main point of the present paper, we may ask whether it is accidental that the difference in aspiration in the unmarked stops of Danish vs. American children corresponds to the difference between adult Danish vs. American stop consonants? Complete answers will not be attempted in the following but a few points related to the problems presented will be touched upon.

In proposing an articulatory explanation for the priority of the unaspirated unvoiced stop, Kewley-Port et al. (1974) point to the timing complexity as an important factor, and state (p. 203): "The hypothesis is that short voicing lag stops are in specific ways easier for the infant to produce successfully than the other two types", (viz. voicing lead and long voicing lag).

In search for evidence in favour of their hypothesis, the authors focus on the timing relations between oral and glottal closure and taking (absolute) initial position as a point of departure, they argue that the correct production of an unaspirated stop makes relatively weak demands on the timing relations between oral and glottal closure, the only condition to be fulfilled being that at the time of oral release the glottal adduction should be completed - leaving freedom as to exactly when it is finished. The requirements for obtaining a correct production of both a voiced and an aspirated stop are stronger, since the same freedom of timing is not permitted here. For a successful production of an aspirated stop it is required that the glottal adduction starts no earlier than at the time of oral release.

The voiced stop requires glottal adduction to be completed at the time of onset of the oral closure - probably with the addition of an active widening of the pharyngeal and oral cavities. In evaluating which of these three types requires the highest degree of precision, it seems justified to leave aside the voiced one as it demands the use of extra mechanisms not needed in the other two. Now, considering the unvoiced aspirated and unaspirated stops, it is not obvious that the aspirated stop requires more precision than the unaspirated one, if there are no con-

straints on the degree of aspiration. In fact, it may be argued that the precision of timing required for the successful production of an aspirated stop is no greater than the precision required for an unaspirated stop, since the adduction in the aspirated stop may take place at any time after the release of the oral closure - the only consequence of the delayed adduction being a longer aspiration. Thus the aspirated stop may be said to permit more freedom of timing than the unaspirated one. Only if a fixed degree of aspiration is required can the aspirated stop be said to imply less freedom (i.e. higher precision).

To solve the problem of the different degree of complexity in laryngeal adjustments in aspirated and unaspirated stops, we must also consider them in a wider range of phonetic contexts than just word-initially after a pause. In a position between voiced segments, the glottal abduction should be considered too. As demonstrated by e.g. Kagaya et al. (1975), most often the abduction starts at the same point in time relative to the oral closure in aspirated and unaspirated stops, thus offering no help in deciding which is the more complex.

Finally, EMG data have been referred to in support of the view that the unaspirated stop is more simple than the aspirated one. A detailed discussion of the arguments shall not be attempted here. Instead, it seems appropriate to raise a few fundamental questions concerning the way in which EMG data are interpreted as evidence of phenomena such as ease of articulation and simplicity in general: Does a sudden forceful increase in muscular activity imply more effort (less ease of articulation) than a less sudden and less forceful one? Can the activity of one muscle - several muscles are known to function antagonistically - be viewed separately? If only the interaction of different muscles is of interest, how is then this complex interaction evaluated? Not until questions of this sort have been satisfactorily answered would it be safe to use EMG data in discussions concerning articulatory complexity, general articulatory difficulty, ease, or the like.

Giving unambiguous articulatory substance to expressions such as ease of articulation is evidently a difficult task but also an important one for our understanding of both first language acquisition and language in general.

As demonstrated by data presented by Fischer-Jørgensen (1979), the boundary in terms of VOT between the two categories (i.e. aspirated vs. unaspirated) is often found to be at 50 ms or even 60 ms in the speech of young subjects from the Copenhagen area. The absolute VOT values are, however, greatly influenced by factors such as place of articulation of the stop consonant (velars showing the longest and labials the shortest aspiration)[1], and the quality of the following vowel (the longest aspiration is found before high vowels). The younger subjects of the Fischer-Jørgensen investigation were from 25 to 30 years old, and it may be hypothesized that the tendency towards long aspiration in the unaspirated stops is more pronounced among still younger subjects - this, however, has not yet been systematically investigated.

Comparing the VOT system of relatively young adult speakers (as given by Fischer-Jørgensen (1979)) with the VOT system of the two-year-old children (as presented in this investigation), the two systems turn out to be almost coinciding. It is natural that such a coincidence takes place at some stage of the linguistic development, what is surprising is that it takes place at this early stage considering the "deviant" nature of the adult system.

In conclusion, if there is a universally and naturally unmarked VOT range of 0 - +30 ms, the period of time during which it is preferred by Danish children must be extremely short and occur very early in their linguistic development, since at the age of two it has already moved into the +50 ms range.

On the other hand, it may be hypothesized on the basis of the present data that the unmarked range extends beyond +30 ms VOT. If this is the case, it has implications for the analysis of the adult VOT system of e.g. American English. One consequence is that for that language, all of the unvoiced and (almost) half of the occurrences of the aspirated stops are comprised in the proposed unmarked region. Such a discrepancy between naturally unmarked regions and boundaries compared to what is found in actual languages is hardly acceptable.

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1) It is interesting to note that this is not always the case in my investigation of the children's speech.

6. Linguistic observations of children younger than two years

Since the children at the day nursery at which the recordings took place were between 6 weeks and three years of age, it was possible to observe the linguistic behaviour of children younger than those selected for the present investigation. The following are impressionistic observations of the aspiration in the stops of very young children:

At the end of the first year of life, the first few words with aspirated stops are produced (these may even be among the very first recognizable words of the child's speech). However, only a minority of the words with adult aspiration is produced with an aspirated stop by the child. The majority of these words contain an unaspirated stop in the child's speech. When aspirated stops do occur they almost always do so in words with aspirated stop in the adult language. The relatively few words with aspirated stop in the child's speech is pronounced with aspiration whenever pronounced - exceptions were found to be very few.

The observations reported above are in conformity with what other investigators have found, e.g. Ferguson et al. (1973).

Finally, it should be pointed out that making linguistic observations of very young children is a difficult task. One of the main problems is to decide whether a given vocalisation uttered by the child is to be characterized as babbling or a (reduced) linguistic word. It is of no help, of course, to ask the child if a given semantic content is attached to what was uttered; and making use of e.g. games always implies the addition of other factors than the linguistic one. The decision is made solely by the observer and not necessarily in conformity with what was intended by the child.

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