

FO DECLINATION LINE: MORE EVIDENCE FROM INFANTS' AND CHILDREN'S SPEECH (9-48 MONTHS)

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ABSTRACT

In this study, we examine the Fo declination line (FoDL) in full term and preterm babies, between the age of 9 months, when a child still babbles, and the age of 48 months when a language with longer and complex sentences is already acquired. Two main situations of communication were chosen: solitary babbling/ interaction with adult. An instrumental analysis (Pitch detection, Fo curves) was conducted, a linear regression on all detected Fo values was computed and its significance tested statistically. The first results show that both situation of communication (solitary vs interaction with an adult) and age influence the presence and use of FoDL. Also, full term and premature babies seem to behave differently. The physiological and phonological aspects of the FoDL in communication and language development are discussed.

1. INTRODUCTION

Is the Fo declination line (FoDL) constrained physiologically as an intrinsic feature of pitch or does it depend on linguistic constraints [1]? Despite many studies on this problem, the answer is still controversial. The existence of the declination line and its origin are still regularly put to question.

Our purpose is not to examine the different answers or to discuss them, but to provide some new elements taken from our long ongoing studies on the acquisition of language. These could throw some light on this problem. To the best of our knowledge, the existence of the FoDL has never been studied at the beginning of language, particularly in very young children's speech. Thus, it would be useful to know if it is a physically innate phenomenon or if it is acquired and if so, when. It should be recalled that FoDL has been found even in the productions of non human primates [2].

In a preliminary case study [3] the FoDL was examined in one baby between the age of 9 months, when the child still babbled, and the age of 36 months when a first language, with some longer and complex sentences, was already acquired. To the variable "age" (V1), was added the variable "situation of communication" (V2). Two main situations were chosen: non communicative solitary gibberish and productions emitted in interaction with an adult. Two groups of hypotheses were put forward: a) in the gibberish style FoDL should not be present because there is absolutely no constraint on these productions, not even on voice quality, going from (low) creak to (high) screaming; in interactive productions, on the contrary, there should be at least some evidence of FoDL; b) FoDL should be linked with age; it should appear more and more clearly as the child gets older. The first results seemed to show that our hypotheses were for the most part upheld. The percentage of items showing the presence of a slope (with a p-value <0.01) was directly correlated to the FoDL phenomenon. The "situation of communication" variable was found to be a significant factor. The same conclusion hold for the "age"

variable; the percentage values were increasing as a function of time. The older the child, the higher the value. Age, i.e. acquisition and use of more and more linguistically elaborated productions, seemed to determine wider amount of productions presenting the FoDL phenomenon. So, the general conclusion was: "as the child *gets* more control on his/her productions (acquisition phenomenon) or *needs* more control in order to better communicate (interaction with an adult), the FoDL is getting more frequent. The greatest limitation of these conclusions was the limited number of items and children and thus, the necessity of complementary data to eventually assess the tendencies

2. THEORETICAL ELEMENTS

Pike [4] was the first one who noticed the decrease of Fo through time (drift). Later, Cohen & t'Hart [5] used the term "declination" to describe the same phenomenon.

The points of view differ on how to model this line (one line to join the Fo minima or two lines ? The first one joining the Fo minima-baseline, the second one joining the maxima-topline). Moreover, there is no agreement on how to explain this phenomenon. The aerodynamic theory gives account of FoDL by a decrease of subglottal air pressure (SGP). This point of view was discussed by Collier [6] who showed that the Fo variations are not directly connected with the decrease of SGP. The physiological theory completes the aerodynamic theory by showing that during the expiratory activity of phonation, the lungs reject some air quantity, causing a relaxation of the cricothyroid muscles, and consequently an FoDL [7].

Another point is to know if the speaker has a control (even if he/she has no consciousness of it...) on the FoDL [8]. Thorsen [9] showed that FoDL varies according to the utterance type: it is more important for declarative (assertive) utterances and almost flat for interrogative ones. Collier [8] showed that some FoDL properties are used for linguistic aims: the slope of declination line varies with the length of utterance, resetting at the syntactic constituent boundaries (see also [7],[9],[10], [11], [12]). According to these previous works, the speaker certainly preplans his/her utterances. However, it should be noticed that all the works listed above studied the FoDL using read aloud speech material, i.e. non spontaneous speech. However, this phenomenon seems to be also present in spontaneous speech material (see [12]; [13]-for Dutch; [14] -for Moroccan Arabic).

3. SPEAKERS, SPEECH MATERIAL AND HYPOTHESES

3.1. Speakers.

They were chosen according to three main variables: birth (full term/ premature extremely low birthweight babies

(ELBW)), age (from 9 to 48 months), situation of communication (productions in interaction with an adult/ solitary babbling S.B.). Due to technical reasons, the number of children in each group as well as the number of the productions which could be studied is quite different (see table 1 for details). Most of the full term babies were extracted from a larger sample of children studied transversally, who have been extensively analyzed in previous studies for all their prosodic parameters, i.e. duration of utterances and syllables, syllabic structure, temporal structure and rhythm (Konopczynski [15], [16]), melodic structure, vocal development ([15], [17]). On the contrary, the eight ELBW were followed up at 9, 24 and 42 months; they are matched with eight full term babies. The ELBW were chosen because one knows that they often have problems in fine motor control. Thus, comparing them to full term babies could show some differences in FoDL if this phenomenon is physiological, as FoDL is a fine control of the larynx. These babies have been studied for diverse aspects of their production: it appeared that they are often delayed in the emergence of canonical babbling, and in the control of different prosodic cues [18]. At the ages of 24 and 42 months, they also show a lexical-syntactic dissociation, reflected by the fact that the lexical development is similar to the development of the full terms, but their syntactic-prosodic development is delayed [19]; their main problem seems to be at the phonetic level, which may be due to neurophysiological problems or phonological awareness (Konopczynski & Lenormand, work in progress). In both cases, studying their FoDL could help to throw some light on the FoDL phenomenon itself.

In the present paper, to test if our hypotheses could hold, we present only 4 groups of results: analyzes are going on and for ICPHS (poster) the whole sample will be presented and discussed.

3.2. Speech material.

As in the preliminary experiment, where only one child was studied in a follow up from 9 to 30 months, the speech material for the present study was made exclusively of spontaneous speech, and all repetitions/imitations were excluded. It was recorded in different situational contexts, but only two situations were used here.

For the babbling stage, from 9 to 12 months, the first situation was solitary non communicative vocal play (SB), where children emit unstable productions. It has already been demonstrated (Konopczynski [15][16][17]) that these productions are mainly vowel-like sounds that have neither rhythmic nor melodic nor vocal structure. It is pure substance, pure play, with exploration of the infants' vocal abilities. It should be added that the eight ELBW babies together with their eight matched full term babies do not produce solitary babbling, because they were only recorded in interaction.

The second situation concerned the children in interaction with an adult. In this case, different types of productions appear, depending on the age and development of the child. Still at the babbling stage, between 9-14 months, they produce proto-language (PL), in which, despite the lack of words, listeners recognize, through the prosody of the utterances, different linguistic modalities, like questions, orders, callings, etc. These productions are totally different from the those emitted in solitary play. All cues show a clear

organization, already reflecting the linguistic structure of the target language. The voice is controlled and fitted into a medium range. Later on, the babies enter slowly referential language, which becomes more and more complex. For the following developmental stages, the children's productions were divided into two main groups: a) production of the first recognizable words (holophrastic stage) and combination of two words (words = WO). b) longer "sentences" or utterances, with more than 3 words (longer utterances = LU).

3.3. Hypotheses.

In the situation of non structured solitary babbling, our hypothesis is that FoDL should not be present (see Introduction). In the second situation, our hypothesis is that in Proto-Language there should be at least some evidence of FoDL, even if it is not quite clear or stable. Then, the FoDL should become more and more clear as the children are more and more able to control their voice (physiological level) and as productions are more and more constrained (linguistic level). There should be one exception: late solitary babbling, which presents the same characteristics as earlier babbling, should never show a FoDL.

4. METHOD

An instrumental analysis, including automatic pitch detection and Fo curves (software MES [20]), was conducted. All Fo values were converted in semitones in order to normalize the data. A linear regression on all the detected values of Fo was computed and its significance (p-value) was tested statistically using the *Ects* software (Russell Davidson, 1993. Econometrics Software, Université d'Aix-Marseille II). More details about these original methods will be presented in a forthcoming paper. Analyzed items were splitted into theoretically 48 groups according to the three main variables: birth, age, situation of communication (Table 1). Of course, some groups cannot exist, for instance LU at 9 months, or SB at 48 months. Thus, 35 groups are to be taken into account. Presently, some of them are excluded from the analyzes because of a too small number of items.

For all the groups dealing with SB or PL, the speech continuum was splitted into breath groups as the nature of the vocal productions prevent any verbal segmentation (words, sentences, speaking turns, etc.). On the contrary, for the groups in which verbal material was found, data was segmented according to classical criteria such as the presence of pauses and/or syntactic and semantic coherence.

5. RESULTS AND DISCUSSIONS

As already said, only 4 comparisons, the most significant ones, will be discussed here, as the work is still going on. The first results seem to show that our hypotheses are for the most part upheld.

According to our method, the percentage of items showing the presence of a slope (with a p-value <0.05) is directly correlated to the FoDL phenomenon. The figures in table 1 (horizontal lines) show that the percentage values are increasing as a function of time. The older the speaker, the higher the value. For (almost) the same communication context, age (i.e. acquisition and use of more and more linguistically elaborated productions) seems to determine wider amount of productions presenting the FoDL phenomenon.

The "situation of communication" variable cannot validly be discussed, as the number of items is presently too small; nevertheless, there seems to be a difference, the FoDL slope being significant in less cases (58%) in SB than in PL or WO. Looking at these two variables, it could again be said that, as the child *gets* more control on his/her productions (acquisition phenomenon) or *needs* more control in order to better communicate (interaction with an adult), the FoDL is getting more frequent, but this conclusion has to be checked with more items.

The main differences can be observed for the variable "birth": in the category PL for instance, which is well represented in the productions of the ELBW children, who still produce much more PL at 24 months than the full term babies at the same age [18], the FoDL is worse at 24 months in the ELBW group than in younger full term (15-18 months); this shows that the ELBW children seem to have problems with fine motor control.

Some results do not seem to confirm our hypotheses. It was proposed that the Fo slope should get greater from PL to words (WO) to longer utterances (LU). At the age 28 to 35 months, the reverse appears in the full terms, and the same phenomenon is found in the ELBWs at 24 months. This apparent contradiction could be explained as follows: around 2 1/2 years, the full terms produce quite often a quick and fluent PL, without words, or with non recognizable quasi-words, but very close to French by its prosody. Thus a declination line is present in most cases, as in "real" speech. At the same age, their word combinations and longer utterances are still hesitating, the fluency is not good; hence a significative FoDL in less than 50% of the cases. For the ELBW babies, things are different: at 24 months their PL is not a fluent speech-like PL as in the full term babies, but a "proto words" PL. Hence the slope of this PL is the same than the slope of the words (39% significant slopes). Their LU are even more hesitating, and the number of significant slopes decreases. If this argument holds, things should change at an older age; this category is being studied presently.

Obviously, other dimensions might play a role in the eventual control of FoDL: emotional (all the ELBWs were recorded with their mother, at the hospital were they were nursed, while the full terms were recorded at home; many studies show that an hospital environment is stressing for a child) and physiological state, links with the adult, short and/or long term goals of the interaction, etc. However, this problem is not specific to child language...

If these preliminary results are confirmed by further investigations on larger data and other languages, we could then assess that the FoDL phenomenon is also one of the consequences of the acquisition of vocal strategies (especially prosodic ones). The emergence of these communicative behaviors could then be reinforced by contact situations with adults, especially for the ELBW babies who have problems in some motor control capacities as well as in linguistic achievements and who thus need more interaction with responsive adults than other children. Another interesting

point should be to know if a FoDL is also present in interactions with other children.

A remaining question is to know if this attitude is only mimetic or if it *integrated* in a communicative strategy, i.e. in this later case, FoDL should definitely be considered as a phonological phenomenon even if its origins can be found in aerodynamic and physiological constraints. Here too, ontogenesis can shed some light not only on acquisition and development of vocal and verbal behavior, but also on universals and specificities of languages... and speech.

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	non-matched children						matched children					
	full term						full term			ELBW		
	9-14	15-23	24-27	28-35	36-47	48	9	24	42	9	24	42
SB	SGO	7/12 58%	SGO									
PL	SGO	9/13 69%	SGO	12/15 80%			SGO	SGO	SGO	6/9 67%	16/42 39%	SGO
WO	SGO	2/3 67%	SGO	6/9 67%	SGO	SGO	SGO	SGO	SGO	0/2 0%	49/124 39%	SGO
LU		4/7 57%	SGO	23/49 47%	SGO	SGO	SGO	SGO	SGO		17/58 29%	SGO
NC	2-4 ?	1	8	4	4	8	8	8	10	8	8	10

Table 1. General data table. Scores and percentages of FoDL according to birth condition, age (in months) and type of production. SB: solitary babbling, PL: proto language, WO: one or two word(s) utterances, LU: longer utterances, NC: number of children, SGO: study going on; x/y: total number of items/items with a significant FoDL (p-value <0.05); %: percentages of significant FoDL values.