AERODYNAMIC EFFECTS ON SECOND LANGUAGE ACQUISITION

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ABSTRACT

While languages normally select VOT values for their stop series from three possible categories—long lead, short lag and long lag, most languages prefer adjacent pairs. English, with primarily short and long lag stops contrasts with Spanish (and many other languages) which exhibit lead and short lag pairs. Israeli Hebrew is one of a few languages which may exhibit the extreme values. Speakers of voicing lead-type languages do not need to adjust their voiced stops to produce comprehensible English, but two different studies reported here show that speakers of such languages do indeed begin to produce a significant number of short lag stops for velar targets. We suggest that the increased physiological effort required to sustain transglottal airflow while the supraglottal tract is obstructed relatively close to the glottis (as with velar stops) explains the spontaneous devoicing of velar stops by bilinguals acquiring an English-type system.

It is generally understood that languages have available three categories of stop `voicing'. Using the terminology adopted by Lisker and Abramson [1], we find overall three possible categories: voicing lead (a relatively long period of voicing before release of the articulators), short lag (a relatively short period of voicelessness after release of the articulators--the lag can vary from none at all to roughly 30 ms) and long lag, a relatively long period of voicing following the release of the articulators. It is well-known that the VOT systems of languages differ systematically within these quite constrained parameters. As [1] and numerous others have shown, most languages tend to belong to one of two possible types—voiceless aspirated vs. voiceless unaspirated as one choice (Mandarin, German, probably English) and voiceless unaspirated vs. voiced (French, Italian, Russian) as the other. This is documented extensively in [2]. We also find, of course, languages such as Thai and Hindi with all three categories, but this paper will be limited to consideration of only the two-category languages, which Maddieson, [3], shows to be the majority of languages in his survey

As pointed out in various places (e.g.[4], [5]) languages seem to prefer the use of adjacent VOT contrasts. Maddieson, [3], finds that of the 162 languages in his survey which have a two-way contrast, 72% have a lead/short lag contrast. The vast majority of remaining systems (exact percentages are unavailable) consist of short lag/long lag contrasts. Research reported in [5] indicates that very few languages seem to opt for a contrast between voiced and aspirated stops without the presence of the intermediate category.

One of the languages which has been reported as belonging to the set of lead/long lag languages is Israeli Hebrew, although the exact degree of aspiration within the so-called aspirated series is somewhat in doubt. [6] argues that Israeli voiceless stops are not aspirated but [7], [8] says they are, at least to some extent. Recent instrumental studies also show the presence of aspiration in the voiceless stops, although there is some variation in the results reported.

On the other hand, Spanish is a classic lead/short lag language, with all voiced stops showing long voicing lead, and all voiceless stops showing short lag (data can be found in [1] and numerous other locations).

Bilinguals present an interesting question. What happens when speakers of a language with one system confront a second, conflicting system? We know that speakers of Spanish normally transfer their Spanish system to their English, at least at the early stages. [9], [10] has shown that eventually Spanish speakers acquire the aspirated category.

although he reports that they do not modify their voiced stops towards the English system of short lag for `voiced' stops. In a recent study ([5]) it was found that bilingual Israeli Hebrew speakers maintain their voiced stops at traditional voicing lead levels, but that their voiceless stops seem to take an intermediate value between short and long voicing lag.

In several studies carried out by the authors we have investigated voicing lead in the acquisition of English, and we find that the results are somewhat more interesting. In the first study, [4], a longitudinal examination of the initial stops of Spanish first-language speakers was reported. In that study speakers of various dialects of South American Spanish produced English words with initial stops twice during their period of study at Southern Illinois University, with an interval of eighteen months separating the taping. The first set of data contained long voicing lead stops for all three points of articulation, but the second set of data showed considerable movement at the velar point of articulation. Here we find a significant number of `g' tokens produced with short lag values. Almost fifty percent of the /g/'s were produced with a positive value for VOT.

The second study we will report deals with an apparently balanced bilingual speaker of Israel Hebrew and American English. The subject speaks both languages with no apparent accent. The Hebrew values are exactly what one would expect from a speaker of Israeli Hebrew (see Table 1)

Table 1. VOT values for Hebrew stops of English-Hebrew bilingual.

VOT	Bilabial	Dental	Velar
Vcd	-112.8	-137.9	-73.6
Vcl	50.3	54.7	99.6

Here we can see that the voiced values fall well within the normal voicing lead range, while the voiceless values are a little short for voiceless aspirated values, but much too long for `short' lag.

Much more interesting, however, are the values for English stops (Table 2):

Table 2: VOT values for English stops of English-Hebrew Bilingual

VOT	Bilabial	Dental	Velar
Vcd	-109	-116.3	-22.9
Vcl.	60.8	95.5	119.8

While the voiceless values are typical aspirated stop types, and the voiced bilabial and dental values are almost identical to the Hebrew set, the velar is radically different. And in fact we have a case where the mean obscures a bimodal distribution. We found the following (Table 3):

Table 3: Individual VOT values for English /g/ target.

	Short Lag	Long Lead
	33.5	-72.7
	45.8	-127.7
	36.8	-52.1
	45.1	
Mean	40.3	-84.1

Clearly our subject has a significant number of short lag `voiced' stops, with a mean VOT well within the short lag value for velars (which tend in general to have longer VOT lags than labials and dentals).

Again we have found a pattern that velars do not seem to fit into the VOT category of the other two stops in cases where there is a conflict of systems. Interestingly, this pattern also occurs in looking at overall phoneme inventories. Maddieson says [3] that among those languages which have voiced stops, /g/ is much more likely to be missing than /b/ or /d/.

Why should the velar stops be somehow resistant to voicing? And why only in conditions of instability such as in second language acquisition? One possible explanation can be given in terms of aerodynamics. In order for vocal-cord vibration to take place, it is necessary for air to flow past the vocal cords. In order for airflow to occur, there must be a sufficiently large supraglottal cavity to permit the air to go there. In addition, some change in the size of some air cavity is required to produce the airflow in the first place. Of course, the act of expiration would cause some airflow, but since we are dealing with stops, unless the supraglottal cavity expands there is no region of reduced pressure towards which the air can flow. In the case of labial and dental/alveolar stops there is the general oral cavity, and a number of researchers have found that there are slight gestures of oral cavity expansion accompanying long lead stops. Westbury, [11], Bell-Berti, [12] and Bell-Berti and Hirose, [13] have presented evidence of slight openings of the jaw, expansion of the cheeks and elevation of the velum accompanying voicing of stops. Westbury and Keating, [14], present a computer model of vocal tract aerodynamics confirming the claim that extra effort is required to maintain voicing during closure.

For velar stops, however, we have only limited use of the above supraglottal gymnastics, since most of the oral cavity is blocked off by the velar contact. Thus cheek expansion, and jaw opening will not increase the size of the pharyngeal cavity (although velar raising might). Consequently, it requires considerably more effort to produce truly voiced velars than voiced versions of the other points of articulation.

If we assume that speakers are always attempting to reduce the amount of effort they are required to produce, we can suggest a possible reason for the fact that voiced stops in acquired English would be vulnerable to pressure for devoicing. In English there is no contrast between long lead and short lag stops, and most dialects of English show somewhat free variation between them, with a preference for short lag versions. Interestingly, no one has ever investigated the conditions that govern the variation in voicing of `voiced' stops in English in any detail.

In any case, English, in a sense, `doesn't care' what kind of voiced stops it uses. Spanish does, and Hebrew does, but if we assume that speakers are under constant pressure to do as little as possible, these bilinguals have apparently succumbed to the articulatory desire to reduce effort by modifying their English velar stops to the easier, short lag VOT values.

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