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Are homonyms in consonant cluster productions caused by articulatory or perceptual processes? A discussion based on one child's development

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This paper discusses the development of one child's productions of homonyms caused by two processes traditionally labeled consonant cluster reduction and simplification from the viewpoint of the co-occurrence of a shift in independent articulatory features of the pre-vocalic consonant.

1. Introduction

The child's path towards an ability to produce initial consonant clusters has previously been described as involving, perhaps optional, stages of application of the processes 'cluster simplification' and 'cluster reduction' (for instance Grunwell, 1987). The process of 'cluster simplification' is described as a deletion of all but one members of the cluster, resulting in a unbranched syllable onset. In this stage of development, the child's production of the target word [sto:] would be transcribed as [to:]. At other, usually later, stages of development, applications of the phonological process of 'cluster simplification' changes the child's output form of the cluster, perceived by the adult transcriber, is the voiced cognate of the plosive. E.g. [sto:] would in this stage be produced as [do:]. In both instanced, the output form of the child is often perceived and transcribed by the adult observer as homonyms of the child's output form when the target word does have an unbranched syllable onset with either a voiced or a voiceless plosive in initial position. It is, however, unclear whether the productions were intended to be homonyms due to an identical underlying representation in the child, or whether the child simply fails to make a distinction in the two output forms that are strong enough for it to be perceived by an adult observer.

In order to investigate this, the established acoustic cues of the phonological feature differentiating between the child's output form and the adult output form will have to be investigated in order to determine the which level of processes are involved at various stages in development. In the case of consonant cluster reduction and simplification, the primary candidate for this difference is the voicing contrast. Therefore, the utilisation of the acoustic cues to this contrast may be studied in order to gain insight into the reasons behind the homonyms produced.

2. Voicing cues in adult speech

When reviewing the literature it becomes apparent that the production of a phonological voicing contrast in plosives is a complex process, and that it demands control over a large set

of articulatory processes. In one of the earliest acoustic studies on plosives in a cross language perspective , voice onset time (VOT) was identified as a salient measure associated with the voicing contrast (Lisker and Abramson, 1964, 1967). It was hypothesised that the single acoustic measure of VOT reflected the two articulatory features that had been identified with voicing in plosives at that time, viz vocal fold vibration and aspiration.

Subsequent research has shown that there are more acoustic correlates of phonological voicing in plosives. A summary by Diehl and Kluender (1987) lists a large number of different acoustic correlates to voicing contrast in English word-initial plosives, including voice onset time (VOT) and F0 onset frequency, duration and intensity of aspiration onset frequency and direction of transitions for F1, F2 and F3, and rate of formant transitions for F1 and F2 at the onset of voicing.

3. Development of a voicing contrast in children

Given the large set of unique combinations of acoustic cues which enables discrimination between voiced and voiceless plosives, it is not self evident that a child, which is exposed to a given language environment, will have direct access to the primary methodology used by adults when producing a distinction between voiced an voiceless segments. On the contrary, one would assume that the entire set of established acoustic cues to voicing in adult speech constitute a catalogue of features which the child will have to learn how to combine in order to produce the desired output segment. This, in turn, implies that a large number of possible developmental routes exist for a child towards a contrast in segmental voicing, possibly involving stages of productions that in which the child is attempting to produce an adult-like feature, but fails to reach an adult-like quality in the production of the acoustic cue.

In order to increase the detailed knowledge of the development of production in between the stages where the child is producing consonants with acoustic features in the adult ranges, a number of researchers has undertaken acoustic studies of voiced/voiceless consonants uttered by children at different stages of development. The acoustic feature investigated in these studies has mainly been VOT. For instance, Kewley-Port and Preston (1974) investigated the distribution of VOT in apical plosives produced by three normally hearing, english-learning, children aged 45-101 weeks. The results showed that at 45 weeks of age, VOT was concentrated at the approximate range traditionally associated with voiced plosives in English. The number of long lag VOT productions was, however, gradually increased throughout the investigated age range, showing signs of gradually approaching the adult behaviour of production established previously by Lisker and Abramson (1967). Kewley-Port and Preston (1974) proposed that the reason for the general trend in VOT distribution may be found in the underlying physiological mechanisms involved in voicing production. According to their proposal, a short lagged VOT, associated with a voiced plosive in English and Swedish, is comparably easier to produce since the process of closing the vocal folds can start long before the release of the plosive. This is in contrast to the production of a long lagged VOT, as in a voiceless plosives, where the closure will have to happen at the approximate time of plosive release in order for it to be completed within the range of a voiceless plosive in English.

3.1. The development of a voicing contrast as a function of place of articulation

In an investigation of the development in the voicing production in one male Swedish child, Karlsson et al. (2002) investigated the acoustic output produced by the child between 18 and

32 months through monthly recordings. Using black and white picture prompts, target words with pre-vocalic plosives that were voiced and unaspirated, voiceless and aspirated or voiceless and unaspirated (in an sC-cluster) were elicited by one of the child's parents. The investigated acoustic variables included voice onset time, aspiration duration and rate of formant frequency change at onset. See Karlsson et al. (2002) for methodological details.

Karlsson et al. failed to find an overall developmental pattern for aspiration duration or rate of formant frequency change in the investigated age range. However, regarding VOT, Karlsson et al. (2002) found that at the age of 18-27 months, there was a strong tendency for VOT in the produced initial plosives to fall into the short lagged or pre-voiced range, regardless of the voicing quality of the target and place of articulation (Karlsson et al. (2002), figure 1). In fact, only 5 out a total of 102 plosives produced before 28 months had a VOT value of more than 40 ms. After the age of 28 months, however, a gradual increase in VOT was observed in response to velar target words was observed for all categories investigated (i.e. voiced unaspirated, voiceless unaspirated and voiceless aspirated stops). This increase in VOT was not observed for bilabial and dental places of articulation, giving tentative support for this being a indication of a change in strategy of production in a way which mainly affected segments produced in the velar place of articulation. This general pattern of development has been observed previously in children learning to speak English. In the results presented by Macken and Burton (1978), one of the four investigated subjects followed a similar pattern of development, with an increase in long lagged VOT productions for velar plosives starting earlier than for labial and alveolar plosives. It should, however, be noted that the two remaining subjects who did show signs of acquisition of a voicing contrast in the investigation by Macken and Burton (1978), provided an entirely different pattern of development compared to the subject `Tom'. These subjects instead produced plosives with a long lagged VOT in the labial and alveolar plosives before producing the same pattern for velar plosives.

Given the difference in developmental patterns provided by results from Macken and Burton (1978) as well as the gradual progression towards an adult-like differentiation in VOT shown by Kewley-Port and Preston (1974), the question arises whether there are additional links between the development of a voicing contrast and the development of other articulatory features, such as place of articulation. A clue to this issue may be found in the results presented by Karlsson et al. (2002). Reviewing the data presented in Karlsson et al. (2002) one finds that at the age of around 28 months, the investigated male child was starting produce progressively longer lagged VOT plosives when the adult target word involved a velar plosive. This behavioural pattern was not, however, present in the productions when the target word included labial or dental plosives. The question therefore arises whether the observed shift in tendency should be regarded as an indication that the child has changed its underlying representation due to an added awareness of some feature in the adult output form.

Clues to this distinction can be found in the progression of the child's overall production towards the adult target. An analysis of the transcribed productions made for the targets in each cell in figure 1, i.e. all combinations of the three investigated places of articulation against the three investigated combinations of the phonological features [voice] and [asp], at the investigated ages does reveal an interesting pattern. Table 1 shows the investigated child's trail of productions towards the velar target words "skal", "kal" and "gal". Before the age of 29 months, produced plosives are mainly produced at the dental and glottal place of articulation. Furthermore, vowel productions more or less evenly distributed across the open [a] and [A] vowels. After the age of 28 months, however, place of articulation shift rather abruptly towards a velar place of articulation. Some glottal stops are, however, still present at the end of the investigated time frame. In addition to the shift in consonant place of

articulation described above, the syllable nucleus is also stabilised to a target-like quality. Furthermore, a similar pattern of shift in quality in the initial plosive is also observable for labial and dental data when the target word included an initial cluster at the approximate age in months when the child starts producing plosives with a long lagged VOT.

Table 1: Transcription of production made by the investigated child in response to target words with a velar plosive onset at ages 22-31 months. The time of shift in VOT found by Karlsson et al. (2002), is indicated by a horizontal line after 28 months.

	Age in months										
Target	22	23	24	26		27	28		29	30	31
'Skal'	[dɑː]	[ʔɑː]	[ʔɑː]	[dɑː]		[doː]	[dɑː]	[ʔɑː]	[kɑː]	[dɑː]	[ʔɑː]	[kχɑː]
'Kal'	[ʔa]	[ʔɑː]		[dɑː]	[ʔɑː]	[boː]	[dɑː]	[ʔɑː]	[kɑː]	[χɑː]	[kɑː]	[kɑː]
'Gal'		[gɑː]	[dɑː]	[ʔɑː]		[dɑː]	[dɑː]		[kɑː]	[ʔɑː]	[kɑː]	[kχɑː]

4. Conclusion

Based on the developmental pattern observed in the VOT of plosives produced by one child, it is conjectured that the co-occurrence of a shift in VOT and a shift in place of articulation at the age of 28 months, might be taken as an indication of a reorganisation regarding the internal representation of the target word due to a perceptual process rather than an affect of articulatory development. The plausibility of this conjecture is increased by the two different developmental paths for English learning children described by Kewley-Port and Preston (1974) in terms of place of articulation of plosives where a VOT contrast is initially shown.

If the validity of this conjecture can be confirmed, through further analysis of a larger set of subjects, it may serve as an important clues as the nature of homonyms in children's productions of consonant clusters.

5. References

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