SIBILANT~VOWEL COARTICULATION IN THE PERCEPTION OF SPEECH BY CHILDREN WITH PHONOLOGICAL DISORDER

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ABSTRACT

Two experiments, compare sibilant labelling functions of Phonologically Disordered children (PD) with those of normally developing (ND) peers and adults. Results show that ND childrens' labelling becomes more adult-like from 5 to 8 years and that as a group, PD children have less ability to classify 'within category' stimuli than their ND peers. They are also less able to switch to intrinsic fricative cues if transitional information is compromised by masking.

INTRODUCTION

Because speech contains multiple clues to the identity of the same contrastive unit, present not only in the speech segment which most closely maps the 'phoneme' itself but also in adjacent segments, listeners can theoretically gain the same semantic knowledge by having access to different sets of cues, that is by employing different sets of sampling strategies.

The initial experiment exploits these concepts of trading relations and perceptual salience and measures the contribution of intrinsic, transitional and vowel context perceptual cues, to the listeners assignation of identity to varyingly ambiguous fricatives taken from a synthesised /s~ʃ/ continuum. Nittrouer and Studdert-Kennedy [1] using similar methodology were able to chart the developing sensitivity of ND children, to acoustic variation in the speech signal, showing that children were more influenced by transitional information than adults and less able to make use of steady state cues. They were also less likely to take into account the acoustic consequences of following vowel on sibilant quality [2].

These response were also considered to have implications for language acquisition theory, indicating that young children are more aware of cues that are instrumental in binding the "syllable" together, than those which describe specific segmental features.

The second experiment tests the flexibility with which the subject groups can employ acoustic cues, using a masking technique - reverberation. This is designed to encourage the listener to employ a strategy which focuses more on steady state features rather than transitional information to resolve the ambiguities arising [3], the hypothesis being that PD children are unable or less able to make use of these cues than their peers.

METHOD

Stimuli

The stimuli comprised 54 single words combining synthesised noise taken from a 9 step fricative continuum with the transition and vowel excised from three naturally spoken word pairs, She/Sea, Shoe/Sue and Shore/Sore. The words were chosen to allow comparison with previous findings [1], the Shore/Sore pairing being also included in case the more fronted quality of the Scottish /ɤ/ was not sufficiently contrastive with /i/ to produce a measurable vowel effect.

The words were produced by a Scottish male speaker, recorded using a Sony TCD D3 DAT tape recorder with a Sony ECM S220 electret condenser microphone. The signal was digitised at 10kHz.

The continuum, a bipolar model, was generated using a Klatt synthesiser with the peak frequency of the prominent pole varying in steps of 180 Hz between 2,400 Hz and 3,840 Hz. Three tapes, one for each vowel context, were prepared for the first experiment, with each of the 18 Fricative/Transition/Vowel groupings being presented 10 times in random order.

A reverberation time of 1.2 seconds was imposed on the tapes electronically, to form the stimuli for the second experiment. This resulted in increasing the vowel duration of the stimuli by an average of 270%. In addition, spectrographic analysis showed obvious temporal smearing or 'overlap masking' [4] of the fricative over the following vowel and internal smearing or 'self-masking' of energy within the vowel itself. This had the effect of flattening the transitional trajectories.

Subjects

Table I indicates the composition of the clinical groups. The children, all living within the Edinburgh area of Scotland, were diagnosed by their referring clinicians as having developmental phonological disorder [5], with no evidence of dyspraxia or structural malformation. Two of the children (one in each of Groups PDa and PDb), had moderate learning difficulties, otherwise all children had language comprehension and use of syntax at a level within or above that expected for chronological age.

Table 1. PD Groups, according to age.

Group	Age	
PDa	4y7m-5y6m	9
PDb	5y7m-6y6m	8
PDc	6y7m-7y6m	4

Their performance was compared with 27 ND children, all attending mainstream nursery or primary schools and without a history of referral to the speech-language therapy service. These subjects formed 3 groups according to the age ranges described in Table 2.

Table 2: Composition of the ND Groups.

Group	Age	Sbj.No.
NDa	4y7m-5y6m	9
NDb	5y7m-6y6m	9
NDc	6y7m-7y6m	9

The adult group comprised 10 Scottish speakers, and was unbalanced for age, gender or pre-test performance criteria, to produce an appropriate normative base against which to measure developing and clinical behaviour.

All subjects but one (a PD child in group PDc, who had a unilateral hearing loss of 30Db) passed an audiometric screening test (ANSI, 1973) [6] as part of the experimental protocol.

Procedure

The 6 tapes were presented binaurally, at a comfortable listening level through Sony MDR 84 headphones and subjects were asked to identify each stimulus as one of the word pair, beginning with either 's' or 'sh'. For adults, testing took place either on the same day or consecutive days, at their convenience and they were asked to write down their responses. A ten minute break was allowed between hearing each tape with a thirty minute gap between the third and forth tape, if testing was completed in one day. Children in the oldest ND group were able to hear two tapes in one day, with a break in between, but the other children heard only one tape per day and either one or two tapes per week, according to parental preference. These children's responses were scribed.

All subjects heard the tapes presented in the order Shoe/Sue, She/Sea, Shore/Sore, with the normal signal heard first. Testing for each subject was completed within an eight week period.

DATA ANALYSIS

Subjects produced 10 responses for each of the 9 different fricative tokens per transition-vowel context per tape. These scores, converted into percentage 's' word initial responses, per stimulus token, constituted the data for the analysis. Probit transformation was applied to the individual responses of each subject, producing a labelling function for each of the twelve contexts (from here described in the format (Ô) or (s) indicating transition, i,u,o indicating vowel, R indicating reverberated). This procedure fits a cumulative normal (sigmoid) curve to the proportion scores by a method of least squares [7], which estimates the mean and standard deviation for each distribution. The most ambiguous physical stimulus value on the fricative continuum, the 'phoneme boundary', corresponds then to this distribution mean and is referred to as the 'intercept'. The 'slope' of the probit regression reflects the slope of the labelling function at the phoneme boundary. In categorical labelling experiments, the slope of the resulting regression is normally regarded as an index of

consistency of response, with the present paradigm however the shallower slope is taken as an index of salience of transitional material. [8]. Statistical effects were tested using a repeated measures design. Levene's tests were used to examine homogeneity of variance.

RESULTS

Intercepts (See Figure 3)

A comparison of the Adult and ND groups showed no significant difference in pattern of response according to age across contexts. In line with previous findings [1], intercept values were higher when vowels were preceded by (ʃ) transitions [F(2,78), 17.23, p<0.0001]. The effect of reverberation had a moderating effect on transitional influence, reducing the intercept value resulting from a (ʃ) transition and raising the value in the (s) condition, (Signal*Transition [F(1,39)=8.643, p=0.005]. Planned comparison of Adult v NDa (4y7m-5y6m), showed a significant effect of Transition*Age [F(1,17)=5.017, p=0.039], indicating that transitional information was more salient for the youngest group.

Planned contrasts between the ND and clinical groups, showed a significant difference between the performance of the two oldest groups. (NDc v PDc, [F(1,10) = 10.621, p=0.009] Their response to transitional information was also distinct (Transition*Group) [F(1,10)= 26.861, p<0.0001), transitional influence being more marked in the responses of the PD children.

Slopes (See Figure 4)

The main effect for Age across the Adult and ND groups was significant [F(4,39)=32.347, p<0.0001] and linear [F(2,380)=13.615, p,0.0001], confirming that slope values decreased significantly with decreasing age. The main effect for Signal was not significant, reverberation having a tendency to sharpen slopes for the adult and NDc groups but lower them in the case of the two youngest groups. Planned comparison between Adult v NDa was significant for Signal [F(1,17) = 6.029, p=0.025].

Planned contrasts between ND and PD children showed significance differences in the responses of the two oldest groups. (NDc v PDc, [F(1,10) = 13.008, p=0.005], NDb v PDb [F(1,13)= 8.723, p=0.011]. Clinical children had less sharp labelling functions, indicating the greater salience of transitional information on their judgement.

CONCLUSION

Intercept and slope measures derived from the labelling functions of Adult and ND children indicate that transitional information becomes less salient with increasing age. Reverberation mitigates the effect of transitional information for older children and adults but results in shallower labelling functions for younger children. The youngest PD group showed similar functions to age matched peers. Responses became increasingly different from ND peers, with age.

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Figure 3. A comparison of group mean intercept values per context for the adult control and age matched ND and PD groups. Responses to the normal signals are on the left and gridlines provided, for reference at intercept = 5.0.
PDc with NDc- 6;7-7;6yrs, PDb with NDb- 5;7-6;6yrs, PDa with NDa- 4;7-5;6yrs,

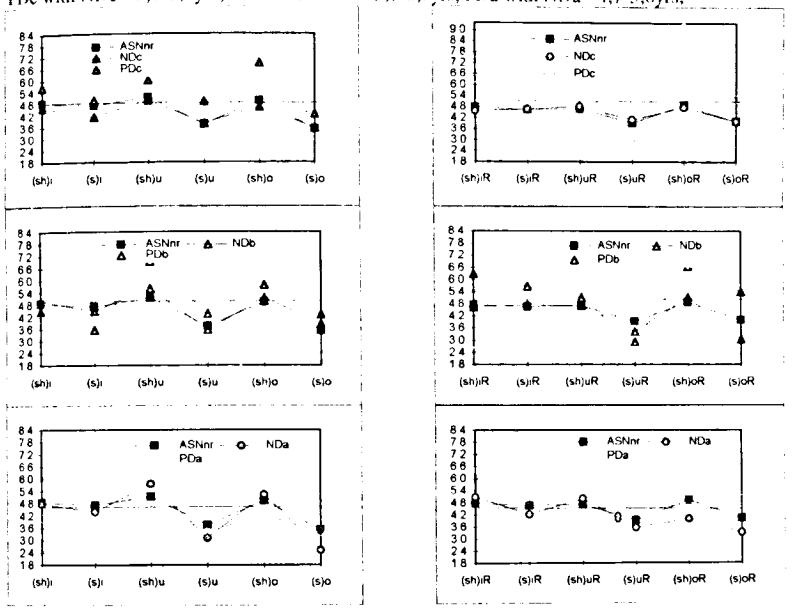

Figure 4.: A comparison of group mean slope values per context for the adult control and age matched ND and PD groups. Responses to the normal signals are shown on the left.