TESTING SUBPHONEMIC PERCEPTION PROCESSES IN CHILDREN SUSPECT FOR AN AUDITORY DISORDER

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ABSTRACT
Currently available speech perception tests provide insufficient insight into type and cause of an auditory processing disorder. The paradigm of categorical perception which discriminates an auditory- and a phonetic stage, combined with the idea of reducing redundancy of speech stimuli in order to have access to speech processing, enables us to develop a new tool for fine-grained assessment of central auditory pathology. By now, the first steps have been taken in the development of the test consisting of a series of experiments on verbal dyspraxic children, reading and spelling disordered children and children with a severe history of otitis media.

1. INTRODUCTION

Several categorical perception studies on auditory perceptual behaviour in groups of children with a specific speech- or language disorder have shown a deviant response pattern as compared to a normal control group. Auditory processing disorders, without there being a hearing-loss according to tone- and speech-audiogram, have manifested themselves in a delayed speech- and language development. Currently available speech perception tests, generally containing tasks based on monotic measures (e.g. filtered speech, competing signals), dichotic measures (e.g. syllables, words, sentences) or tests of binaural functionality (e.g. binaural fusion, rapidly alternating speech) give insufficient insight into type and cause of such a disorder. This article concerns the first steps in developing a new tool for fine-grained assessment of speech perception processing.

The paradigm of categorical perception provides for the base of a more sensitive and analytical test. According to this paradigm, a continuüm of speech stimuli covering a phonological contrast is constructed by digitally manipulating a single acoustic cue. The central idea is that perceptual boundaries arise along the physical continuüm, with qualitive resemblances within each category and qualitive differences between them or in a more modern psychophysic sense [2], there is a quantitative discontinuity in discrimination at the category boundary, as measured by a peak in discriminative acuity at the transition region of adjacent categories.

Two starting-points for research are of interest. Firstly, the speech perception model of Pisoni and Sawusch [3], which differentiates between a pre-categorical or auditory stage and a categorical or phonetic stage, plays an important role. During the first, auditory stage, listeners take in short stretches of the raw acoustic signal and make a preliminary auditory analysis. No speech segments have yet been identified. In the second, phonetic stage listeners examine their auditory memory and combine the acoustic cues to form a phonemic representation. This stage preserves the nature of the identification but does not preserve the acoustic cues upon which it was based.

By comparing identification and discrimination performance (labeling words and telling them apart) we can derive the level of the auditory disorder. Discrimination scores can be predicted on the base of identification scores [4]. Assuming that the listener bases discrimination judgements only on phonetic information, the observed discrimination scores should correspond to the predicted ones. If the subject has access to auditory precategorical information, the discrimination scores should be higher than the predicted scores.

Secondly, we assume that a speech perception problem may be caused by a neurological reduction of the redundancy of the auditory processing system [1] which we call the internal redundancy of the perceptual system. During speech perception there has to be a considerable reduction of the internal redundancy before stimuli with their normally high external redundancy (which is implicit in the normal structure of the acoustic speech signal) cannot be identified anymore. The conclusion is that the external redundancy must be reduced such that the speech perception test becomes more sensitive to small reductions of the internal redundancy.
Exactly this occurs in constructing a speech-continuüm, a word (one end of a phonological contrast) is transformed to another (other end) bij systematically decreasing and increasing the salience of the acoustic cue.

A speech continuüm will contain stimuli which do not discriminate between normal and pathological groups. In order to maximize the efficiency of the testprocedure and to minimize effects of response bias these stimuli can be eliminated out of the test. Only the critical stimuli, the stimuli which are as sensitive to account for differences between normal and deviant children will be included in the final test. Sensitized speech stimuli can be singled out of stimuli near the phonemeboundary.

2. PROCEDURE

By now the first steps in developing such a sensitized perception test are being carried out. We examine scores on tests where two acoustic cues are systematically varied: VOT (/bak-pak/, i.e. BOX-PACKAGE) and place of articulation, second and third formant transition (/bak-dak/, i.e. BOX-ROOF).

Three experimental groups are tested:

- verbal dyspraxic children aged between 6 and 11 years. These children show dysfunctions in the programming of their articulomotoric organs. We suppose that (a part of) this group is marked by a central auditory dysfunction.
- children with reading- and spelling problems, 2 groups; one in the age of 6-7 years, the other in the age of 8-10 years. Disordered auditive functions could be one of the main causes of the problems.
- children with a severe history of otitis media with effusion (OME) in the early childhood (aged round 2 years). At the time of testing they are 6-8 years of age. Due to temporary conductive hearing-loss these children show disorders in their auditory deve-

lopment. We take interest in the extent in which the central auditory functions are affected. Our experimental design is based on a division into 4 groups: a) Children with an OME-history and with a delayed speech- and language development, b) Children with an OME-history and without a delayed speech- and language development, c) Children without an OME-history and with a delayed speech- and language development and d) a control group children without an OME-history and without a delayed speech- and language development.

3. RESULTS

At the time of writing this paper only the data of the verbal dyspraxic group have been fully analyzed. For, at this time, lack of data of a control group we shall present in this paper some examples of identificationcurves of the place-of-articulation continuüm /b-d/ of a male adult without hearing problems or a delayed speech- or language development with a normal response pattern and a verbal dyspraxic child with a abnormal response pattern (figure 1).

Remarkable is the less steepness of the slope of the curve of the verbal dyspraxic child compared to the adult. We interpret this as a less consistent labeling ability, pointing towards a processing dysfunction at the phonetic level. In figure 2 the corresponding discriminationcurves are presented. Again there is a difference between the verbal dyspraxic child and the adult; the ability to discriminate is less in the verbal dyspraxic child. Furthermore the overall form of the discriminationcurve doesn't agree with the foneemboundary found in the identificationcurve.

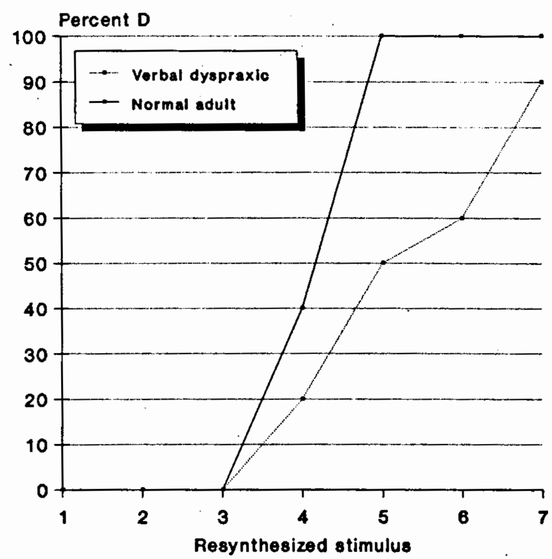

Figure 1. Identificationcurves of a normal hearing adult and a verbal dyspraxic child (dotted line).

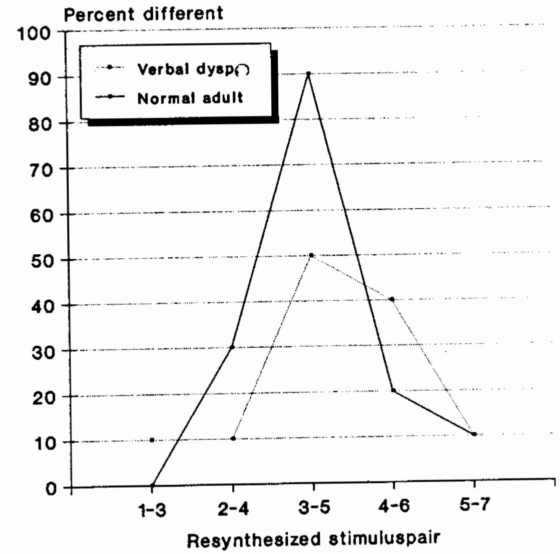

Figure 2. Discriminationcurves of a normal hearing adult and a verbal dyspraxic child (dotted line).

Taken together, this verbal dyspraxic child shows a disordered auditory stage (less discriminative power), followed by an inadequate functioning of the phonetic stage (less steep slope, shifted phoneemboundary), partially an effect of the malfunction in the auditory stage.

If we take the group verbal dyspraxic children as a whole, there's a great variability in scores suggesting the possibility of dividing the group in a number of verbal dyspraxic children having speech processing problems and a number of verbal dyspraxic children showing no central auditory dysfunction.

More elaborated analysis of the experimentai groups, yet unavailable, will be given at the presentation.

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