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Does training with manipulated stimuli improve auditory perception in non-typical language learning children?

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Severely language-impaired school aged children and matched controls were trained with stimuli either selectively time/spectrally manipulated or embedded in noise, S/N=3 dB, during 4-5 weeks. Comparison between pre- and post training scores on a battery of language tests showed very significant improvements for both groups. No significant difference was found, on the other hand, between the two groups. The good training results for both groups may be attributed to a general focus on speech and language, rather than training with specific acoustically modified stimuli.

1. Introduction

Some children show language-processing deficits despite normal development in other areas as evidenced for example in poorer performance in various speech perception tasks (see Bradlow et al. 1999 for an overview; Mody et al. 1997 and Mody, 2003). Several of these studies found impaired perception of short synthetic CV-stimuli in children with learning problems, especially under demanding conditions. The roots to some of such perception problems have been proposed to stem from deficits in general temporal processing mechanisms (Tallal, 1996) or related to phonological processing of linguistic material (e.g. Mody, 2003). Training with stimuli aimed at compensating for the proposed temporal processing deficits have been successful in some reports (Tallal, 1996; Merzenich, 1996), while others have met with difficulties in replicating these results (Mody et al. 1997; Lacerda and Lindblom, 1999). Specifically, Tallal and colleagues (1996) argued that speech perception deficits to a large extent are related to difficulties in processing rapid auditory stimuli such as short formant transitions in CV-syllables. These authors developed a training program, Fast ForWord (FFW) (Scientific Learning Corporation) where the speech signal was prolonged by 50% and the 'transitional elements of speech' (ibid. p. 81) were differentially amplified up to 20 dB. The present study aims at further explore the potential value of training programs for severely language-impaired children (SLI) with manipulated auditory stimuli.

2. Method

The subjects' language profiles were measured pre and post implementation of the training program, using a battery of 19 standard language tests to obtain the abilities of word coding,

comprehension, rhyme recognition, syllable and phoneme segmentation and phoneme identification and deletion, to mention some.

2.1. Subjects

All the participants were enrolled in a special resource center for severely language impaired children and diagnosed as suffering from general severe language impairment, language impairment, severe speech delay or general language impairment as assessed by a professional team of speech pathologists, speech therapists and psychologists. The subjects varied greatly in cognitive profiles but performed well within the normal intellectual range. The subjects' chronological ages ranged from 9 to 14 years. 24 subjects were split into two matched groups according to the results of the test battery and their chronological age.

2.2. Stimuli

The stimuli consisted of manipulated pairs of natural recordings of VCCV sequences forming non-words and in which the medial consonant segments in the second sequence were reversed, e.g. [øljø / øjlø]. The vowels were either [ø] or [ɛ]. Two female women speaking standard central Swedish read the non-words. A total amount of 1443 stimuli were prepared, half of which were masked by noise, S/N=3 dB, and the other half were slowed down by 50%, band pass filtered by a filter bank simulating the 21 Bark bands and amplitude processed within each band to enhance by up to 20 dB the onset amplitude contrasts. The aim of this latter manipulation was to create stimuli similar to those used by Tallal et al. (1996), (below called the TT stimuli).

2.3. Training procedure

The prepared sound stimuli were implemented in a commercial computer based education program. The training period lasted over 4-5 weeks, a total of 16 sessions. In the 16-20 min. long sessions the children used the stimuli in a variety of exercises and games. General adjustments such as number of answer alternatives and time availability were made before each session and the exercises were planned on a weekly basis to ensure individually adapted increase in task complexity. One of the groups, Group N, used the stimuli masked in noise during the training and the other group used the TT stimuli, Group T.

3. Results

The scores of the pre and post training tests were analyzed with Wilcoxon Signed Ranks Test and comparison between the pooled results from both groups revealed very significant improvements in 18 of the 29 tests, a tendency to improvement in 6 (e.g. sentence reading, WRI, phoneme identification and sound synthesis) and no change in 5 (e.g. auditory sequence memory, letter chains and visual repetition). A significant improvement for both groups was shown in the ITPA subtests of the AV-channel ($p < .0001$). The psycho-linguistic age (PLA) was very significantly improved for both groups ($p < .0001$), if calculated on the raw scores, but when calculated in stanine scores this result was only shown in an advantage for Group N over Group.

The between group comparison revealed no differences at all in 23 of the subtests; a very significant difference in advantage for Group N in reduction of the time spent to complete the word reading test; a tendency to advantage for Group N in PLA, auditory reception and word recognition index; and finally a tendency to advantage for Group T in general auditory ability and in the total score of phonological awareness. The results in the latter tests, though, showed large individual differences and were very unstable.

4. Discussion

The significant training effects for both groups in a majority of the language tests indicate that the severely language-impaired children strongly benefited from training with the acoustically modified linguistic material. In a majority of the language tests the post training results showed very significant, or in some cases significant tendencies to improvements. The results from the inter-group comparison are noteworthy with respect to the quality of the specific modifications of the auditory stimuli needed to accomplish such improvements: simply embedded in noise or manipulated according to Tallal's et al. transform (1996). While earlier studies have failed to find support for Tallal's et al. proposed hypothesis of 'temporal processing deficits' in terms of increased formant transition durations (Mody et al. 1997; Lacerda and Lindblom, 1999 e.g.) and yet Tallal et al. (1996) for example, report successful training results. The SLI children in the present study also improve their language tests scores from training with modified stimuli and what then may be the explanation? No doubt, several factors contribute and one of the most important may be that the use of a variety of games and exercises forces the children to pay attention in a general way to speech and language. The importance of directing of attention may be a fundamental ability in processing mechanisms (Lacerda and Lindblom, 1999). The quality of the speech material after the acoustic manipulations according to Tallal's et al. transform (1996) render the speech signal a strange, vocoder-like character that may make the children more attentive to speech and language per se and the noise-embedded stimuli may have a similar effect. There seems to be no solid theoretical or experimental support for a positive perceptual effect of e.g. prolonged formant transition durations in subjects with language processing difficulties (e.g. Bradlow et al. 1999), even if a general slowing down of the speech tempo often makes the perception tasks easier (Lacerda and Lindblom, 1999).

Listeners with language problems often do worse on some auditory tasks, as mentioned above, performances that have been interpreted as a deficit in general auditory processing mechanisms (Tallal et al. 1996; Merzenich et al. 1996). On the other hand, when using synthetic speech-analogue stimuli, presented to the listener as non-speech, the performance may be equivalent to typical listeners, as reported by, Serniclaes and colleagues (2001) for example. These authors found that children with developmental dyslexia were actually better at discriminating acoustic differences between stimuli that belonged to the same phoneme category, suggesting that these subjects were less categorical, than the average readers. These results might be of crucial importance in discussions about poor performance in language impairments. It seems likely that building up relevant phonemic representations of the speech signal is fundamental to language processing and that weakness in the representations of speech sounds might influence the performance in a variety of language tasks (Mody et al. 1997; Mody, 2003. The formation of rudimentary phonemic representations seem to start early in infancy resulting at the end of the first year of life in an attunement into some (proto) categories relevant to the ambient language (Lacerda, 1992). The increased ability by children with developmental dyslexia (Serniclaes, 2001) to discriminate within-category

stimuli better than average readers, may be a sign of developmental delay in the formation of phonemic representations.

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