Neurofunctional Correlates of Auditory Perception and Discrimination Training at the School Age

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INTRODUCTION

- deficient auditory processing, both verbal and non-verbal, is frequently reported in language-impaired children (LI)
- many LI children have combinatory difficulties: neural processing is slow and a lot of auditory information is lost
- acoustic hyper- or hyposensitivity and increased distractibility are connected with language defects
- in auditory perception the brain's attentional mechanisms select certain stimuli for preferential processing

- event related potentials (ERPs) can be used to reveal neurofunctional correlates related to language acquisition
- mismatch negativity (MMN) is an ERP waveform that indicates attention-independent, perceptual change in auditory modality
- MMN is modulated by long-term memory, and learning effect
- the late MMN component is suggested to reflect difference detection of complex auditory unites

- with ERP recordings it is possible to isolate different phases of auditory processing and behaviorally unreachable cognitive reactions
- we examined the effect of stimulus complexity on auditory ERPs, and changes in MMN elicited with auditory discrimination training (ADT)
- it was hypothesized that intensive training which takes into account the specific features of the auditory perception in LI, will be seen as changes in MMN

METHODS

- ADT is a method to mold auditory processes by means of individually filtered therapeutic music
- filtering is based on pure tone audiogram
- the aim of the ADT therapy is to reduce problems caused by inaccurate hearing, e.g. language impairment and distractibility
- the child is listening ADT music daily at home, 10 minutes per a day
- during the treatment there is usually 3-5 control tests, and new tapes are prepared
- total duration of the ADT-treatment takes about 6-9 months

- ERP recordings with NeuroScan equipment
- oddball paradigm   p= 0.15 for deviants
- non-attend situation: children watching a voiceless videotape
- stimuli delivered binaurally by headphones
- stimulus intensity about 75 dB$_{SPL}$
- constant ISI 500 ms, stimulus duration about 200 ms
- filtering: band pass 0.1–15 Hz
- the early MMN (150 – 350 ms) and the late MMN (350 – 550 ms) analyzed separately

- ERP recording were repeated to all subjects 9 months later (Recordings I and II)

Figure 3. Changes in auditory discrimination and naming. Vowel score max. 32, Consonants max 50 and Boston Naming Test max 60. In discrimination tests the accuracy of 98% is normally reached at the age of 7 years. Statistical difference from reference values is marked with an asterix.
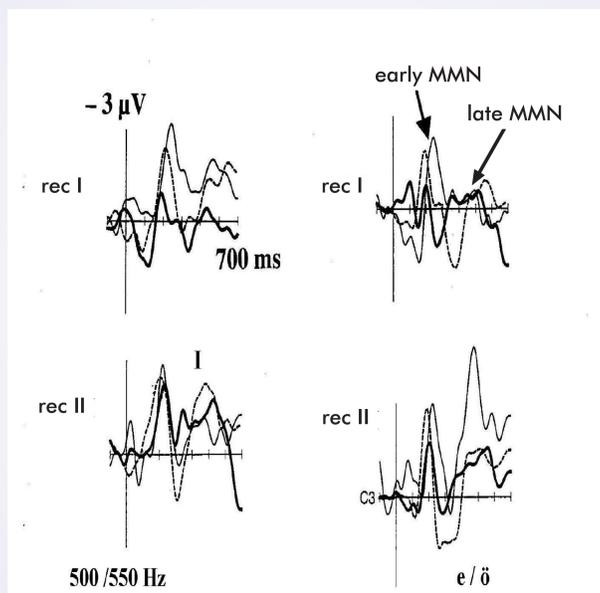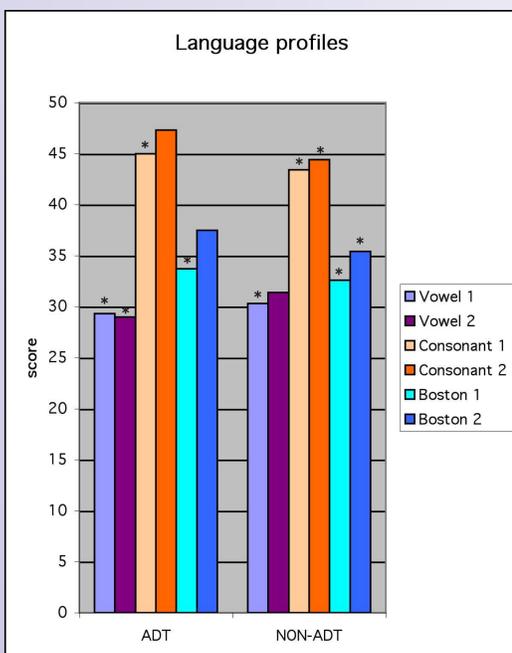
FIGURES AND RESULTS

Figure 2. ERP difference wave, recordings I and II (post-training for the ADT-group). ADT-group bold line, NON-ADT dotted line, controls thin line.

Stimuli	standard	deviant
Pure tones	500 Hz	550 Hz
	2000 Hz	2200 Hz
Vowels	/e/	/ö/
Syllables	/ta/	/ka/

Subjects	ADT	NON-ADT	Controls
	6	8	13

1st – 4th grade, 7-10 years

ADT and NON-ADT: LI & dyslexia

Language tests and behavioral evaluation:
* Boston Naming Test
* Auditory discrimination Test of Finnish Vowels and Consonants
* An assessment of child's attention / behavior / coordination and language development, completed by the teacher and parents

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- the effect of stimulus complexity was seen as longer eMMN latencies in all subjects (Figure 1)
- in LI children eMMN latencies were significantly longer and amplitudes weaker for 2000/2200 Hz and the same tendency was found for 500/550 Hz and the vowel stimuli
- after the training, both eMMN and lMMN amplitudes of the ADT-group normalized, especially for low frequencies 500/550 Hz and vowels e/ö (Figure 2). This was assumed to reflect more accurate auditory difference detection
- at behavioral level, the training effect was seen as better discrimination of consonants and development of naming skills; in these skills ADT-group reached the reference values for the age (Figure 3)
- parents and teachers reported noticeable progress in attentive and language skills in those children whose ERPs were normalized after the training
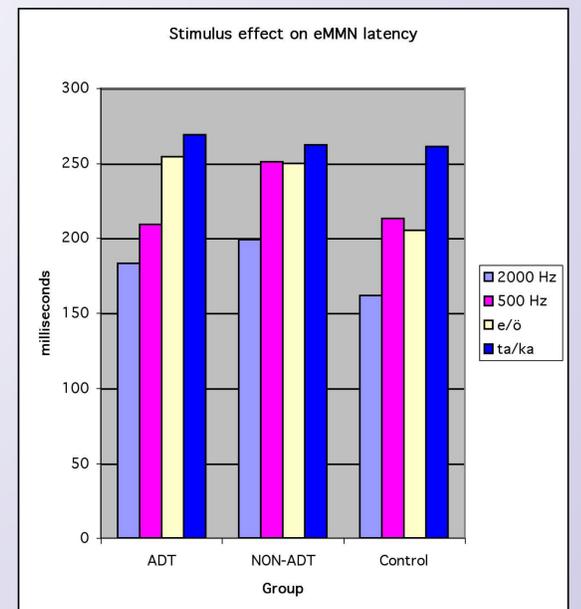
Figure 1. The effect of the stimulus type and complexity on eMMN peak latency, electrode C4 (pre-training condition).

CONCLUSIONS

- perception of auditory stimuli, wheather attended to or not, undergo a rapid and complex cortical analysis
- with MMN research method it is possible to study both elementary and complex aspects of language learning
- ADT training can be used to reach better auditory discrimination and, by that means to help the LI child to acquire language