A single case-study in Helsinki, Finland

This study was planned to evaluate the cortical changes related to specific auditory stimulation. While specific auditory stimulation may not be the only solution to the impaired and distorted audition, it can make the hearing more accurate and improve communication and learning.

Between June 1997 - Feb. 1998 a case study with one five year old severely language-impaired boy was conducted in cooperation between The Sensomotoric Centre in Helsinki, Finland and The Centre for Cognitive Neuroscience, University of Turku, Finland (prof. Pirjo Korpilahti, PhD).

The study was planned to demonstrate the auditory training-driven improvement and cortical plasticity of auditory processes. Event related potentials (ERPs) were recorded in a passive research condition to verify the neuro-functional changes as an effect of specific auditory stimulation.

(ERPs are time-locked changes in the brain's electrical activity to the stimuli and cognitive demands of the research paradigm). Delays in the onset and the latency of auditory ERPs have been reported in language impaired children. The attenuated brain responses reflect poor auditory discrimination (Korpilahti 1996).
The MMN (mismatch negativity) is an auditive ERP wave form which is elicited automatically by changes in a string of standard stimuli. The MMN serves as an index of the accurateness of the auditive difference detection and is modulated by long term memory and training. This component has been found to be very sensitive to auditory variance, even when the deviation is close to the threshold level of perceptual discrimination).

The subject

A 4;9 year old boy with a diagnosis of specific speech and language disorder, especially difficulties in producing and understanding language, impairment in fine motor skills, handedness not established, restless behaviour, difficulties in following instructions and in comprehending speech, fluent but deformed speech, distorted phonemic system. The boy seemed uninterested in drawing and could not ride a bicycle.

Teacher's and speech therapist's assessments

In kindergarten he sometimes joins the group, but mostly he wanders around on his own.

Speech is quite fluent but difficult to understand. He uses some well articulated words and he also has a lot of sentences. His phonological system is impaired and pronunciation is unstable. Words are distorted and often difficult to understand. Comprehension of spoken language is difficult for him.

Prior to therapy the family and some therapists were suspicious that the boy might be on the autistic spectrum.

Clinical assessments

Audiometry showed some variation from the optimum hearing curve (total 150) and left ear advantage for pure tones.

The ERP waveforms were recorded while the boy was watching a silent TV cartoon and the sounds or words were presented via earphones. General ERP waveforms for complex tones showed that the basic acoustic reactivity of the auditory cortex was normal. An involuntary attentional switch was recorded by deviant tones. The Topographic brain map showed two-phasic MMN reactions. The early mismatch negativity was starting from the left hemisphere and expanding to the right fronto-temporal area. In healthy children the right hemisphere is more active in frequency difference detection than the left hemisphere. In this boy the late mismatch negativity was stronger than the early MMN and occurred more centrally. The latency for this component was quite slow for the age.

In the word condition deviant words elicited a negative wave, starting from the left hemisphere. The neural activation was slowly developing over both hemispheres. An involuntary attentional switch was also recorded in deviant words. The MMN pattern was two-phasic and both peaks were maximal at the centro-frontal area. The early MMN peaked in normal timing (150-200 ms) and was followed by late MMN (300-350 ms). The amplitudes of these components were atypically low. In normal children Korpilahti (1996) has reported an integrative time window for the word difference detection. In this case this summating processing, reflecting the lexical difference detection, was missing. Instead this boy was processing single acoustical features inside words - fig. 5.

The stimulation

Based on the recorded audiograms the boy listened via earphones to manipulated recordings of specially composed music (**Johansen IAS**) for 10 min/day over a period of eight months. The first stimulation period (tape one) lasted for 6 weeks. The second period (tape two) lasted for 6½ months.

Results

After the stimulation period the audiogram followed the optimum hearing curve almost perfectly.
In ERP recordings the MMN showed that the difference detection of complex tones was no longer eliciting an involuntary attentional switch to the tone difference. The late MMN was stronger and began earlier than on the recordings prior to the stimulation period.

In the word condition the change in the MMN component was evident. The integrative time-window occurred in the latencies of 300-600 ms after the stimulus onset. The maximum late MMN was recorded at 400-450 ms as in a control group. The left hemisphere was detecting the difference in words and the auditory processing was no longer based on fragmented acoustic information - fig. 6.

The speech therapist reported that the boy's vocabulary had developed. He was using longer sentences and his spontaneous speech had a more correct syntax. The psychologist reported that the boy in kindergarten was now lively, imaginative, good at games, playing appropriately and popular among the other children. He was talkative and enjoyed the attention of adults. He was eager to learn and asked a lot of questions. In face to face situations he understood even quite complicated matters. The psychologist concluded that non-linguistic performance after the stimulation was at the good average level and that linguistic skills were average. The diagnosis of autism was excluded.

Discussion of the Helsinki case-study

This study was planned to evaluate the cortical changes related to specific auditory stimulation. It was found that ERPs can be used to follow and to evaluate the stimulation-driven effects on the auditory cortex. It was also found that the improvements and changes in the boy's total behaviour, not only the language improvements, were very impressive. Specific auditory stimulation may not be the only solution to the impaired and distorted audition, but can make the hearing more accurate and improve communication and learning.

This research was conducted by Dr. Pirjo Korpilahti, now Professor at the University of Turku, Finland.

More research also utilizing ERPs is necessary to validate the findings by this case-study. This is ongoing.