Ear-level FM receiver stimulates auditory neural plasticity in children with APD

Summary

Studies have demonstrated the benefits of ear-level FM receiver use for children with Auditory Processing Disorders (APD). Evidence from a recent experiment[1] now shows long term benefits to central auditory processing and neural plasticity after one year of use of a special ear-level FM receiver. This highlights the role of improving the Signal-to-Noise Ratio for children with APD in possibly accelerating the neural maturation process and increasing speech recognition in noisy environments.

Introduction

Children with APD have difficulties listening in noise although they have normal peripheral hearing. This central auditory deficit results in lowered speech-in-noise comprehension and attention focusing abilities affecting academic achievement negatively. In the past, studies have already demonstrated that the everyday use of a personal ear-level frequency-modulated (FM) device such as EduLink could significantly help children with APD overcome their difficulties listening in noisy environments such as the classroom[2]. One open question was to determine whether the use of an ear-level FM receiver could affect long term neurophysiological changes associated with better sound processing by children with APD. It is possible to study cortical representations of sounds by recording Auditory Event Related Potentials (AERPs). This technique evaluates cortical processing of sounds via objective measurements of brain waves associated with auditory perception. In AERPs, cortical processes show up as a succession of peaks of positive (P) or negative (N) potentials. The N1 and P2 components are amongst others, classical central auditory evoked components[3]. N1 and P2 waves typically reflect sensory processing stages and are modulated by the amount of energy engaged in the processing of a particular stimulus. Typically, the N1/P2 complex of waves is reduced in patients suffering from sensory- or attentional- processing deficits, such as APD. The goal of the reported study[1] was to assess subjective, objective and most importantly, electrophysiological long term outcomes of ear-level FM receiver use in children with APD, to identify potential neural plasticity driven by using such devices.

Setup of the study

10 children aged 7 to 14 as well as 10 age matched control subjects took part in a one-year experiment. All children had hearing sensitivities better than or equal to 20dB HL at 250-8000Hz and normal cognitive abilities (IQ>90). All test subjects had a personal history of learning difficulties and auditory difficulties consistent with APD and attention related concerns. The test group used an ear-level FM receiver (EduLink technology in a BTE housing) at least 5 hours a day, 5 days a week, during school hours.

Different subjective, objective and electrophysiological measures were done at the beginning, 6 months and 1 year after the start of daily FM use. Subjective testing consisted of questionnaires given to the children's parents evaluating the impact of FM use on social-behavioral factors. Objective behavioral measures were obtained from 5 psychoacoustic tests including a frequency discrimination and a side order judgment test. Finally, AERPs were acquired while auditory stimuli (2.2 kHz 2/3 of trials and 4 kHz tones, 1/3 of trials) were presented to children. Each recording session consisted of 100 randomly distributed auditory stimulations.

Results

Subjective social behavioral evaluation

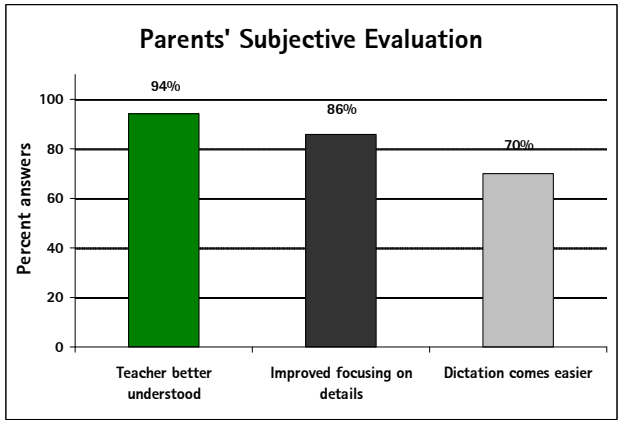

Fig.1: Percentage of positive responses given by parents evaluating subjective improvements.

Figure 1 above shows parents' subjective judgments of their child's social behavior averaged over six visits

performed in 1 year. Subjective improvements were very significant. They judged that thanks to the use of the FM devices their children better understood the teachers in 94% of cases, improved their children's focusing abilities in 86% of the cases and finally made dictation in 70% easier. Altogether, these observations highlight the benefit of daily FM use for children with APD and outstanding social behavioral improvements.

Objective psycho-acoustical evaluation

As figure 2 below shows, 2 of the 5 behavioral tests, namely frequency discrimination and side order judgment (high and low frequency clicks are applied randomly to one or the other ear, participants must decide which tone was presented second), showed significant and constant improvement for children in the FM group compared to children in the control group. The three other tests did not show any significant change. It is interesting to note that these two tests reflect typical primary difficulties people with hearing loss encounter, decreased frequency- and binaural temporal- resolutions.

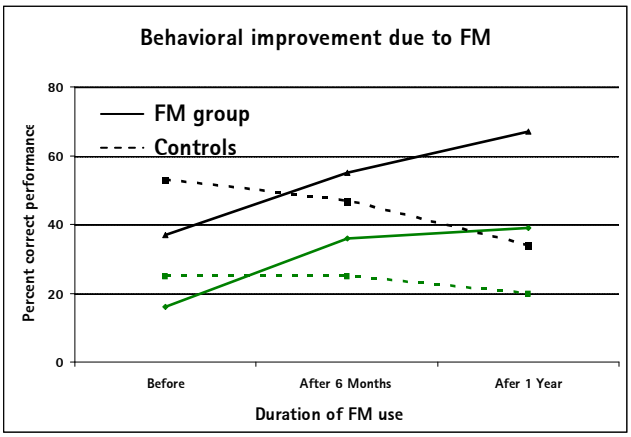

Fig.2: Percentage of correct responses given to two behavioural tests: side order judgement (black) and frequency discrimination (green).

Electrophysiological measures (AERPs)

Electrophysiological results demonstrate a clear positive outcome of daily FM use in children with APD: it appears to stimulate central neural plasticity. Figure 3 below shows the brain potentials obtained from three electrodes for the detection of 4 kHz tones by FM and control children before, after 6 months and after 1 year of ear-level FM receiver use. At the beginning of the study children from both groups showed classical anomalies of the N1/P2 complex, the different waves being hardly recognizable. In the FM group, the maturation of the N1/P2 complex over time is very impressive; in particular, during the year of FM use, in participating children the amplitude of the P2 AERP component increased constantly, which was not the case for children in the control group.

This maturation of the cortical response is likely to be due to the better auditory stimulation obtained by the use of an ear-level FM receiver, which would help the acquisition of more stable and stronger cortical representations of sounds.

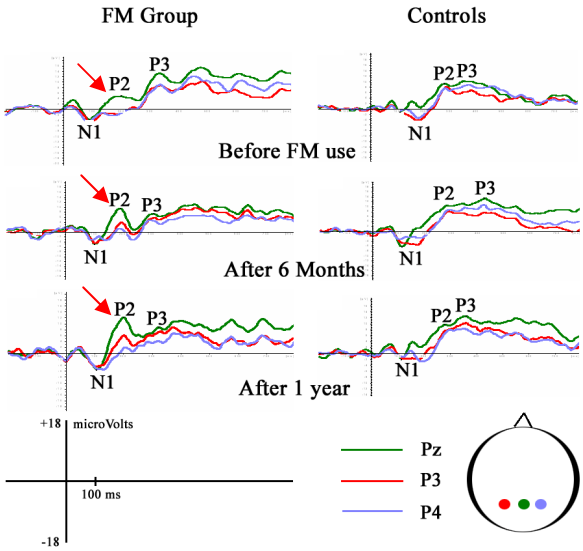

Fig.3: AERP recordings obtained before, after 6 months and after 1 year in FM and control children.
The red arrow highlights the P2 component maturation effect.

Conclusions

In addition to good acceptance and great subjective outcomes of personal FM device use, this study demonstrates that long-term use of such instruments by children with APD may lead to facilitated central neurophysiological plasticity. This phenomenon is reflected in parallel behavioral improvements. These very encouraging observations may give professionals and users hope for real and profound improvements of hearing capacities via the use of an ear-level FM receiver.

References

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[3] Rugg MD, Coles MGH, Electrophysiology of mind. Oxford University Press, 1995.

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