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Changes in children's speech reception thresholds and spatial release from masking from two to four years post sequential cochlear implantation.

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Introduction

Knowledge of long-term outcomes in sequential implantation is needed for candidacy selection and patient counselling. Longitudinal studies to date describe speech outcomes up to two years post 2nd implant only. Up to this point results are asymmetrical across ears, with 1st-implanted ears providing better speech reception thresholds (SRTs) and less spatial release from masking (SRM) experienced if noise is closest to the 1st-implanted ear [1, 2]. This study describes the changes in SRTs and SRM of a group of sequentially implanted children from two to four years following sequential implantation.

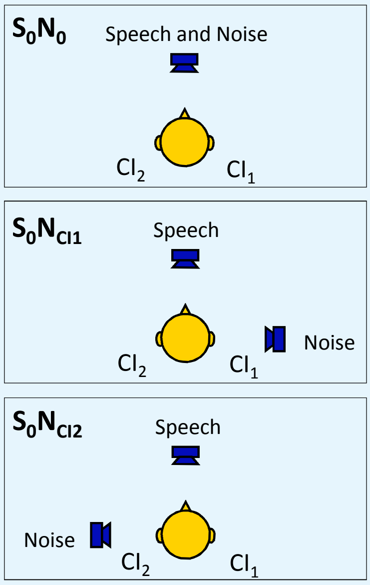
Methods

Participants: We identified 17 congenitally deaf children reported to be consistent users of both a first (CI_1) and sequential (CI_2) cochlear implant. Each child had aided thresholds bilaterally of 35 dB HL or better from 0.25 to 6 kHz and had participated in spatial listening assessment at two and four years post-CI_2. Inter-implant intervals ranged from 19 to 95 months (median = 49 months).

Assessments: Assessments were performed at two and four years after children received their second cochlear implant. Tests were administered via the AB-York Crescent of Sound [3]. SRTs were measured using the adaptive McCormick Toy Discrimination Test [4] monaurally in quiet and binaurally with pink noise. Words were presented from directly ahead and noise from 0°, +90° and -90° (see Figure 1). Children listened to the introductory phrase "point to the" followed by the name of one of ten to fourteen phonemically paired toys, e.g. "tree / key". SRM was calculated in decibels as the improvement in binaural speech reception threshold for noise coming from each side compared to noise coming from directly ahead i.e. $SRM_{CI1} = SRT_{S_0N_0} - SRT_{S_0N_{CI1}}$ and $SRM_{CI2} = SRT_{S_0N_0} - SRT_{S_0N_{CI2}}$.

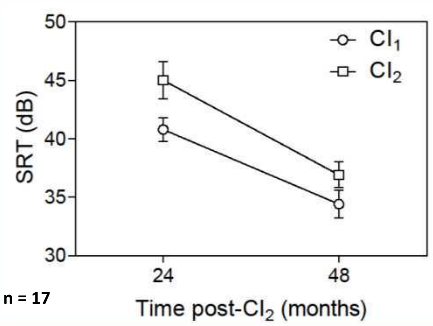
Analysis: Data were analysed via two-level hierarchical regression models with the levels of the model being measurement (within-participant) and participant (between-participant). For each dependent variable (SRT in quiet, SRT in noise and SRM) a series of models were used to explore the effect of explanatory variables (i.e. time post-CI_2, implanted ear and noise location). For multiple hypotheses testing a Bonferroni-corrected significance level of $p < 0.01$ was used. For SRTs in quiet and noise lower values represent better performance. For SRM higher values represent greater ease of listening when noise is spatially separated from the speech signal.

Figure 1: Test set-up for binaural speech reception thresholds in noise



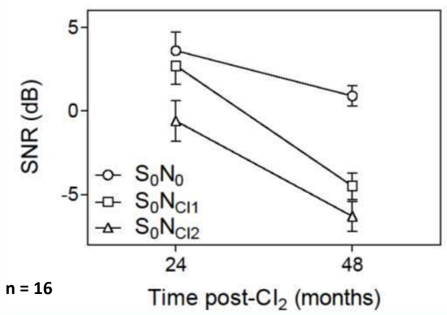
Results

Figure 2: Monaural speech reception thresholds in quiet



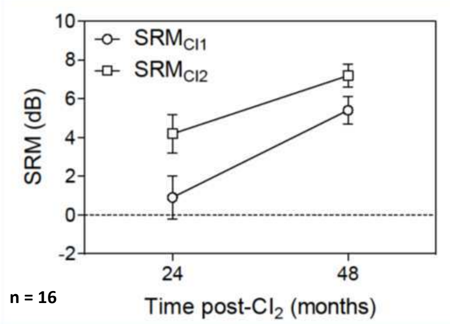
CI_1 ears had lower mean SRT than CI_2 ears at two years post-CI_2. In addition, SRT for both ears improved as a function of time post-CI_2. These observations were statistically confirmed. Both the inclusion of ear ($\chi^2 = 5.46$, $df = 1$, $p < 0.05$) and time post-CI_2 ($\chi^2 = 37.84$, $df = 1$, $p < 0.0001$) caused significant reductions in model deviance. A greater change was seen for CI_2 ears (8.1 dB) compared to CI_1 ears (6.4 dB). However, after four years post-CI_2, CI_1 ears still had lower mean SRT than CI_2 ears.

Figure 3: Binaural speech reception thresholds in noise



At two and four years post-CI_2, lowest (best) mean SNRs were measured at S_0N_{CI2} and highest (worst) SNRs measured at S_0N_0. For all three noise locations SNRs reduced as a function of time post-CI_2. The largest improvement was seen at S_0N_{CI1} (7.2 dB) followed by S_0N_{CI2} (5.7 dB), with a smaller improvement (2.7 dB) seen at S_0N_0. Both noise location ($\chi^2 = 25.91$, $df = 2$, $p < 0.0001$) and time post-CI_2 ($\chi^2 = 51.30$, $df = 1$, $p < 0.0001$) caused highly significant reductions in model deviance. The interaction between noise location and time post-CI_2 was also shown to be significant ($\chi^2 = 10.05$, $df = 2$, $p < 0.01$) confirming the difference in improvements seen across the three conditions. Whilst SRT at S_0N_{CI1} and S_0N_{CI2} were significantly different at two years post-CI_2 ($t = 3.27$, $p < 0.001$), the difference was not significant at four years post-CI_2 ($t = 1.81$, $p = 0.04$).

Figure 4: Spatial release from masking



A clear trend for both SRM_{CI1} and SRM_{CI2} to increase (improve) as a function of time post-CI_2 is evident. Also, a notable difference exists between SRM_{CI1} and SRM_{CI2}, with SRM_{CI2} being greater than SRM_{CI1} at two and four years. However, this difference becomes smaller as a function of time post-CI_2 from 3.3 dB at two years to 1.8 dB at four years. That is, SRM_{CI1} shows a greater improvement than SRM_{CI2} and as a result SRM across ears became more symmetrical over time. Statistical modelling confirmed that both noise location ($\chi^2 = 6.34$, $df = 1$, $p < 0.05$) and time post-CI_2 ($\chi^2 = 17.00$, $df = 1$, $p < 0.0001$) had a significant effect on SRM. The interaction between noise location and time was not significant ($\chi^2 = 0.73$, $df = 1$, $p = 0.39$), indicating that the time-dependent improvements in SRM_{CI1} and SRM_{CI2} were not significantly different.

Conclusions

Speech recognition in quiet and noise and release from masking improved between two and four years post-CI_2. The contribution of CI_2 improved more than that of CI_1 with regard to SRTs, resulting in more symmetrical benefit. This information may be useful in counselling children who struggle to make consistent use of a sequential implant, to encourage them that their listening can continue to improve over the longer term with practice. It also highlights the potential benefits of a CI_2 even for children with up to 95 months of unilateral CI_1 use.

References

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