

BINAURAL IMPLANTATION IN BLIND-DEAF ADULT AND NORMALLY SIGHTED CHILDREN

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INTRODUCTION

The binaural processing of signals offers a number of important psychoacoustic advantages which have a significant influence on the use of bilateral devices.

The main effects could be summed up in:

- Directional hearing (Localization/Orientation)
- Squelch' Effect
- Improved discrimination in noise
- Summation
- Integration (fusion)

All the above mentioned factors lead to better Sound Quality and Ease of Listening.

However, the two main phenomena which bilateral cochlear implantation attempts to restore could be summed up in Directional Hearing and better Speech Discrimination in Noise.

From a physiological point of view, these aims involve:

- The **Head shadow effect**, where the mechanisms involved in localization of a sound source include Inter-aural Time Delay- ITD, Inter-aural Intensity Differences- IID, Duplex Theory etc.^(1, 2, 3). However, for cochlear implant users Inter-aural Intensity Differences would seem to hold greater importance for

localization in that these subjects manage to detect differences as small as 0,2dB in comparison to 0,5-1dB seen for hearing subjects ⁽²⁾.

The Head Shadow effect is particularly significant for frequencies > 1000 Hz. Hence, this can be exploited by bilateral implantation owing to the extended frequency output (<5500Hz) of the device.

- The **Squelch effect** can be explained as the ability to selectively attend to stimuli coming from a primary source while effectively excluding interference from surrounding noise (Cocktail party phenomenon)⁽⁴⁾.

This becomes particularly important in noisy surroundings, and fundamental for better speech discrimination in noise (SNR).

Furthermore, the 'Squelch' effect is closely related to our ability to locate sounds in space even though it also depends on other, more complex, phenomena such as Binaural Masking Level Differences (BMLD).

At present, few studies have been carried out on the above mentioned issues in the light of the effectiveness of binaural implantation also because it has been seen that in certain circumstances the degree of difference between the input to the two ears may be so great that fusion into a unitary image may become almost impossible. This may be a result either of anatomical differences or variables such as duration of deafness, along with factors related directly to the device, e.g. coding strategies, stimulation rate, asymmetrical insertion. In fact, much research is still to be done in this field.

In our opinion there are certain priority categories of subjects for whom we suggest bilateral implantation. These consist of:

- ❖ **Deaf Blind** , who make specific use of acoustic cues for localization and orientation with consequent improvement of quality of life and increased self sufficiency;
- ❖ **Adults with special needs**, relative to work situations or to the presence of intense bilateral tinnitus;
- ❖ **Children**, both deaf-blind and normally-sighted, in order to create the conditions whereby he/she can acquire all the acoustic prerequisites for a more natural and physiological development of language skills.

If bilateral cochlear implantation is undertaken at an early age (<4-5 yrs) it will presumably be possible to take advantage of the child's neural plasticity (typical of this age group) and guarantee the preservation of residual neural structures due to electric stimulation from the implants. This, in turn, should lead to improved speech perception and production, faster learning rates and reduced hearing fatigue.

EXPERIMENTAL STUDY IN ADULTS

In our Implant Centre binaural cochlear implants have been provided for two blind/deaf subjects and one normal-sighted child. Apart from the fundamental factors linked to speech perception and discrimination in noise, in the blind this raises further questions such as the more extensive need and use of auditory cues for localisation and orientation to sound, as well as life quality and consequent cost effectiveness^(5,6).

In a previous study⁽⁷⁾ the mechanisms involved in the use of acoustic cues for sound **localisation (judgement of the direction of a sound source)** and **orientation (movement towards a sound source)**⁽⁴⁾ were compared in deaf-blind and normally sighted profoundly deaf subjects.

Study Group

In order to obtain data relative to various combinations of blind and/or deaf subjects, five main groups were set up in order to get a more thorough knowledge of their use of auditory cues for localisation and orientation both under binaural and monaural conditions.: Blind-Deaf (bilateral CI), Normal-sighted deaf (bilateral HA), Normal-sighted deaf (CI/HA), plus two control groups consisting of a)blind-normal hearing subjects and b) normal-sighted/normal hearing subjects. All cochlear implant wearers had been using their implants for a minimum of 18 months. Age in the study group ranged from 18 to 61 yrs of age.

| GROUP | LOCALISATION | | ORIENTATION | |
|-------------------------|--------------|----------|-------------|----------|
| | Binaural | Monaural | Binaural | Monaural |
| Blind/Deaf CI | 16.1 | 39.9 | 17.5 | 40.2 |
| Deaf/Sighted HA x 2 | 32.5 | 55.6 | 30.8 | 53.1 |
| Deaf/Sighted CI / HA | 45.5 | 55 | 50.2 | 55 |
| Blind/Hearing | 0 | 22 | 0 | 17.7 |
| Sighted/Hearing | 0.6 | 4.1 | 1.6 | 3.7 |

Tab. I: Average results for Localisation / Orientation trials in adults (degree of error)

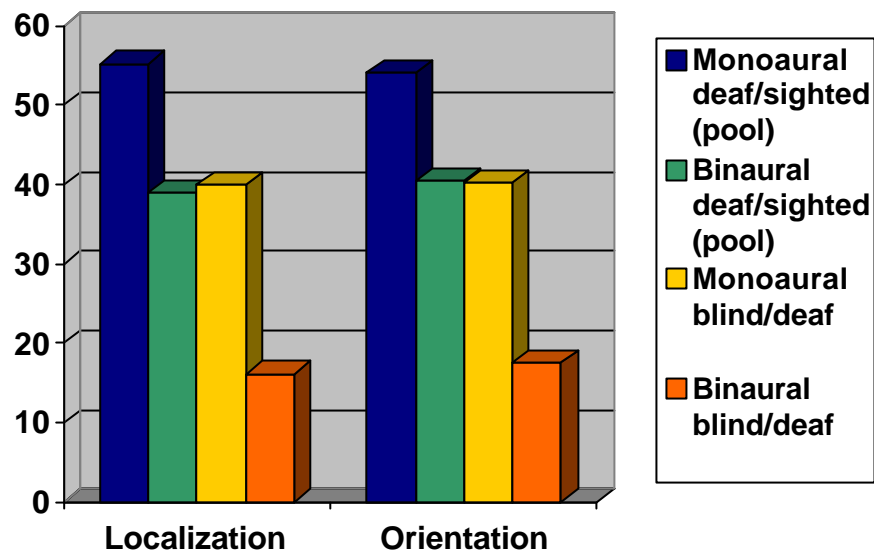


Fig. 1: As can be seen from the following histogram, results here are presented as blind-deaf vs normal-sighted deaf (pool) in order to underline the different use of acoustic cues for space perception in these two main groups under both monaural and binaural listening conditions.

Trials for both Localization and Orientation were carried out using a parabola, characterised by seven loudspeakers situated at head level with the patient at a distance of 2.5 m. Angle of stimulus was determined, on the grounds of a statistically randomized scheme. Audio equipment required no operator since stimulus/recovery times were pre-recorded on a masterized CD, whereas output levels were fixed and remained stable throughout the whole session.

Protocol

All subjects underwent the following test protocol, which was carried out first under binaural conditions, then under monaural conditions using the preferred “dominant” ear (usually the one with best speech discrimination for

open set tests); in the group wearing 1 Implant and 1 Hearing aid testing was also carried out in a 3rd mode using the other device (monaural).

For all groups, testing was carried out at 20dBSL relative to aided threshold for specific condition, thus taking into account possible difference in free field threshold (warble tone) between Implant/Aid and between binaural/monaural listening conditions. The control group underwent trials at a standard level of 60dBSPL (equivalent to MCL for complex sounds), in order to reduce intra-individual variability.

For **Localization** the patient was required to indicate the sound source by pointing to the perceived direction of sound. For **Orientation** he/she was required to move towards the sound source on the chair, while the stimulus was maintained constant.

Materials consisted of both environmental sounds and speech stimuli (e.g. doorbell, sentences 1, cuckoo, sentences 2; traffic, continuous discourse 1, music, continuous discourse 2), presented from the loudspeakers in a randomized sequence. This was the subject of a previous study carried out specifically on deaf and deaf/blind ⁽⁷⁾.

Results and Conclusions

Results were measured by degree of error, hence the smaller the degree of error, the greater use of auditory cues can be implied under the specific experimental condition. Table I and fig. 1 show average findings for Localization/Orientation trials with a clear binaural advantage, especially in the deaf/blind.

From this findings it can immediately be seen how the Deaf as opposed to the Blind showed the greatest degree of error for Localization/Orientation for both Monaural and Binaural Modes. This could be attributed to the fact that normally-sighted deaf subjects are in the habit of using predominantly visual cues for Localization and Orientation and when blindfolded they show

relatively scarce use of auditory cues. Here again it is evident that this is also conditioned by inter-individual variability linked to various factors such as rehabilitation method, lifestyle etc.

Even though the numbers taking part in these trials were too few to enable the Authors to apply formal methods of statistical analysis, owing to the particular characteristics of the subjects in our four main groups, it is possible to draw definite conclusions as to the tendencies found.

In the Deaf-Blind, binaural cochlear implantation would not seem to deter the fusion into a unitary image at a central level as perhaps could have been supposed. The binaural advantage which was manifest throughout formal trials for both Localization and Orientation was also reflected in everyday life situations and confirmed very strongly by the patients. The most interesting observations on their part were mostly relevant to reacquisition of mobility, self-sufficiency and confidence in their own ability to be independent. They are even able to move outside their homes as prior to becoming deaf.

During testing it was interesting to observe a tactic that the Blind (Groups 1+2) and the Deaf (Groups 3+4) often adopted under monaural conditions: in order to facilitate perception of angle of sound source, they swivelled on the chair in the search for origin of sound as if to compensate for the lack of the head-shadow effect. The phenomenon was much more evident in the blind than in the deaf, who often tended only to move the head. To what degree does this massive response influence findings. This should be the object of further study.

Neither duration nor type of stimulus seem to weigh significantly on the outcome of trials. Even though, examining the various responses for each of the single stages of testing, useful information relative to the visual and/or auditory style of each subject can be derived.

In conclusion, having shown that the blind do effectively make greater use of auditory cues for both localization and orientation than do the

deaf/normally-sighted subjects with hearing aids, the Authors conclude that binaural implantation in this group of subjects can indeed offer enormous advantages and consequently better life quality. However, it remains to be said that, in order to verify whether this tendency holds in normal-sighted subjects with binaural cochlear implants, further study will be required both on blind and normally sighted subjects.

BILATERAL IMPLANTATION IN CHILDREN

CASE REPORT:

V.B. is a 3.8 ys old girl, with profound bilateral sensorineural hearing loss. She was positive for connexina C26, but she also had Streptococcus pneumoniae meningitis at the age of 3 months. She was fitted with binaural hearing aids at the age of 8 months, and underwent to oral rehabilitation, with scarce benefit due to the inadequate hearing gain.

At the age of 3.4 years, she underwent bilateral cochlear implantation with CII Clarion® devices, that were applied in the same surgical session. The switch on took place after 1,5 months, and both implant were fitted in the same day. The processor fittings were carried out after 1 and 3 months. It must be underlined that since the first day she naturally accepted both implant and wore them easily.

The preliminary results evaluated after **three months of cochlear implants use** show that this child has a faster learning rate for words and sentences compared to other children fitted with monoaural Clarion® devices (Hi-Focus electrode), using the same strategy (SAS). In particular she is able to use idioms in a spontaneous way and she can recognize bisyllabic words and short sentences in open set.

As far as directional hearing is concerned, results obtained in an experimental set-up (see poster on "A New Test For Auditory Binaural Evaluation In Children", De Seta et al.) show that VB was able to correctly localize 91.6 % of stimuli when wearing both devices. In monaural condition only 28.6 % of stimuli were localized.

In normal daily life she is able to correctly localize and to orientate towards familiar environmental sound sources (telephone, door bell, parent's voices ...).

IS BILATERAL COCHLEAR IMPLANTATION JUSTIFIED IN YOUNG CHILDREN?

In the light of this interesting results, but also considering those shown by other implant centers (8), bilateral cochlear implantation in young children would seem to be justified. It remain a duty for the scientific community to give more convincing answers to the following fundamental questions:

- ❖ **Cost/benefit**
- ❖ **Preclusion of future technology**
- ❖ **Long life expectancy**
- ❖ **Effective improvement of speech perception and production as long as increased learning rate**
- ❖ **Better discrimination in noise**

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