ENVIRONMENTAL SOUND PERCEPTION OF COCHLEAR IMPLANT USERS

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Introduction

Most current adult cochlear implant (CI) users achieve higher open-set speech perception scores post-surgery than pre-surgery, a factor which greatly improves their overall quality of life. There is little published research assessing the ability of CI users to identify environmental sounds, an important skill which also impacts upon a patient's quality of life. This study compared adult CI users to normally hearing (NH) listeners in their ability to identify various environmental sounds.

The Environmental Sounds Perception Test (ESPT) developed for this study was more difficult and more comprehensive than those used in current studies, in order to reduce the likelihood of any potential ceiling effect affecting the results. It was hypothesised that the CI users would score lower than similarly-aged NH listeners on the ESPT.

Method – The Environmental Sounds Perception Test (ESPT)

- Initial version test: 50 sounds, 2 tokens each.
- Variety of sounds - some easier to identify than others.
- Aim was for a more-difficult test than those in previous research to avoid ceiling effects.
- Consideration given to the frequency that the sounds occur in everyday life: Out of the 50 sounds selected, 28 appear on the list of environmental sounds reported in Ballas' (1993) ecological frequency survey.
- 12 of the sounds which were not included on Ballas' list consisted of human sounds, speech, music, & general sound environments. These were excluded from Ballas' survey.
- The other 10 sounds were less-common, but were considered important warning signals (e.g. a fire siren), or had distinctive acoustic characteristics (e.g. breaking glass), or were animal or nature sounds (e.g. a dog barking, or thunder).
- Pilot tested with 5 normally-hearing adults.
- From the results of the pilot trials, 45 sound types were incorporated into the final version of the test. These were then classified into 9 different categories, and are listed in Table 1, below.
- Stimuli were obtained from commercially-available sound databases.
- 2 tokens for each sound type; total 90 items in the test.
- Each of the 2 tokens were different – i.e. derived from separate recordings (e.g. different birds singing), or by sampling different sections of a single waveform (e.g. separate samples from a long extract of traffic noise).
- The length of each token ranged from 2.5 sec (breaking glass) to 12.5 sec (fire siren). Different lengths were used for the different sound types to make the extracts more realistic, whilst providing adequate acoustic information representative of the information available in the normal listening environment.
- Continuous waveforms (e.g. traffic noise) had a 30 ms onset and offset ramp to minimise any distortion caused by a rapid onset and/or offset of the sound.
- For discrete waveforms (e.g. footsteps, door knocks, or glass breaking), tokens of the waveform commenced and ceased at natural silence breaks in the waveform.
- A calibration tone (white noise) was generated at the average RMS level across the 90 sound files.

Method – Subjects

- 24 normally hearing (NH) adults. Age: 23-72 years (M=47.0).
- 13 postlingually deafened adult cochlear implant (CI) users. Age: 29-77 years (M=56.9).
- No significant difference between the ages of the CI and NH subject groups (t-test).
- CI users had >10 mths experience with their device (M=27.9 mths; SD=11.9 mths).
- All CI subjects used the Nucleus CI24R implant, with either the *Esprit 3G* or *Freedom* speech processors implemented with the ACE speech processing strategy.
- Speech perception for CI subjects in quiet (n=11) were:
  HINT sentences – M=83.6% (SD=21.1%); CNC words – M=52.6% (SD=28.7%).

Method – Procedures

- Stimuli was presented through a loudspeaker: 0° azimuth, 1 metre from the subject, ~65dB(A) at the listener's ear.
- Stimuli was delivered via an amplifier connected to a computer. Each token was stored on the computer as .WAV files, and a computer program *('UC_ID')* was used to present the stimuli in random order.
- Responses were entered directly into the program for later analysis.
- Closed-set format – a list of the 45 sounds, divided into the 9 categories, was given to the subject to select from.
- CI subjects tested CI-only. NH subjects were tested binaurally.
- No feedback was given regarding their accuracy, & stimuli was not replayed.
- With two tokens for each of the 45 environmental sounds, test score was out of 90.
- Total test time: ~20 minutes.

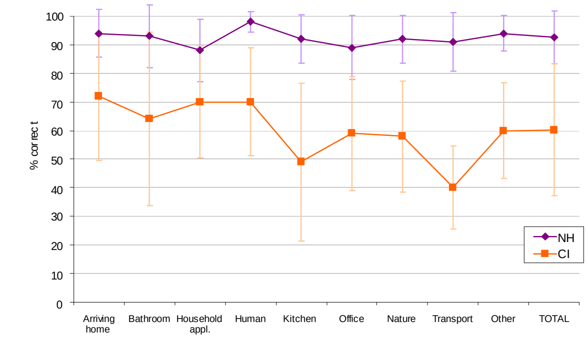
Table 1: Environmental Sounds Perception Test Stimuli

Arriving Home	Bathroom	Household Appliances	Human	Kitchen	Office	Nature	Transport	Other
Door bell Door opening/ closing Key jangling Knock on the door	Running water Toilet flushing Water dripping	Alarm clock Clock ticking Hair dryer Lawn mower Telephone ringing	Baby crying Laughter Footsteps 1 male & 1 female talking at the same time Many males & females talking at the same time Single female voice Single male voice Snoring	Doing dishes Food frying Whistling kettle	Drawers opening & closing Office environment Paper rustling Typing on the computer	Bird(s) chirping Cat(s) meowing Dog(s) barking River/ stream babbling Thunder Wind blowing	Aeroplane Car Horn Fire or Ambulance siren Helicopter Traffic on a busy road Train	Breaking glass Construction site Hand saw Classical music Modern music Restaurant

Results

Mean % correct scores, standard deviations (SD) & range (R) for the ESPT:

Category	NH Group	CI Group
Arriving home	**94%** (SD: 8.23) *R: 75%-100%*	**72%** (SD: 22.33) *R: 25%-100%*
Bathroom	**93%** (SD: 10.90) *R: 67%-100%*	**64%** (SD: 30.31) *R: 0%-100%*
Household Appliances	**88%** (SD: 10.90) *R: 60%-100%*	**70%** (SD: 19.58) *R: 30%-100%*
Human	**98%** (SD: 3.44) *R: 88%-100%*	**70%** (SD: 18.93) *R: 38%-94%*
Kitchen	**92%** (SD: 8.48) *R: 83%-100%*	**49%** (SD: 27.61) *R: 17%-100%*
Office	**89%** (SD: 11.25) *R: 63%-100%*	**59%** (SD: 19.85) *R: 25%-88%*
Nature	**92%** (SD: 8.48) *R: 75%-100%*	**58%** (SD: 19.38) *R: 33%-100%*
Transport	**91%** (SD: 10.27) *R: 67%-100%*	**40%** (SD: 14.50) *R: 8%-58%*
Other	**94%** (SD: 6.14) *R: 83%-100%*	**60%** (SD: 16.83) *R: 33%-83%*
TOTAL	**92.5% (SD: 9.26)**	**60.2% (SD: 23.10)**



2-way repeated measures ANOVA showed:

- Significant difference between CI & NH groups (p<0.001);
- Significant difference for within-subjects factor of category (p<0.001);
- Significant interaction between group & category (p<0.001).

CI group:

1-way ANOVA with Bonferroni corrections showed significant differences between the lowest-scoring category (transport) & the 3 highest-scoring categories:

- Transport & arriving home (p=0.008);
- Transport & household appliances (p = 0.019);
- Transport & human (p=0.022).

Best-recognised sounds were:
Hand saw (100%);
Bird(s) chirping (100%);
Modern music (96%).

Least-recognised sounds were:
Aeroplane (8%),
Wind blowing (15%).

- The most-common confusion was the 'many males & females talking at the same time' stimuli being identified as '1 male & 1 female talking at the same time.'

NH group:

1-way ANOVA with Bonferroni corrections showed significant differences between the highest-scoring category (human) & the 2 lowest-scoring categories:

- Human & household appliances (p=0.007);
- Human & office (p = 0.02).

Correlations (Spearman's rho):

CI group: no significant correlations between overall score on the ESPT, and subject factors of age, speech perception scores, or time with CI.

NH group: no significant correlation between overall score on the ESPT and age.

Discussion & Conclusions

- Along with improved speech perception, the recognition of environmental sounds is one of the most-frequently cited benefits obtained post-implantation. However, this study found that there was still a significant difference between similarly-aged NH adults & CI users in their ability to identify environmental sounds.
- The best-recognised category for CI group was "Arriving home". All 4 sounds in this category were discrete waveforms with distinctive temporal patterns – e.g. door bell, knocking on door.
- The least-recognised category for CI group was "Transport". Except for the car horn, the sounds in this category were continuous waveforms (e.g. traffic noise, train, helicopter), with no distinctive temporal patterns.
- The importance of temporal cues for identifying environmental sounds has also been highlighted in other studies.
- The results also suggest that this environmental sounds test had an appropriate range of stimuli and difficulty levels for further use as a CI assessment tool.
- The study is currently being extended to test HA users who meet the CI criteria. Initial findings suggest that HA users with equivalent levels of hearing loss score worse than the CI users on the environmental sounds test (M = 39.73% correct; n=4).

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References

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