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Research Article

The Use of COSI Questionnaire to Evaluate the Effect of Input Dynamic Range Variables on Cochlear Implant Performance in Postlingual CI Adults

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Abstract

Background: If our goal is to obtain optimal patient performance in everyday life; clinical fitting should improve the cochlear implant (CI) users' ability to understand soft speech as well as speech in noise. It is of great value to change the input dynamic range (IDR) characteristics for CI performance optimization in daily life. Aim of work is to use the Client Oriented Scale Improvement (COSI) questionnaire for evaluation of the effect of different IDR characteristics on CI performance.

Methods: The study group is comprised of fourteen postlingual CI adults who were implanted and used their devices for at least 6 months. Programs were adjusted for four input sensitivity settings differing in threshold (T) and comfortable (C) levels, microphone sensitivity (MS) and volume sensitivity. Subjects were assessed subjectively by using COSI questionnaire 2 weeks after each program setting.

Results: The commonest specific needs in the patient population were firstly to hear conversation with group in noise. Both 3rd and 4th programs revealed the highest percentage of hearing final ability at both 2nd and 3rd important listening situations. This means that patients preferred the programs with the maximum microphone sensitivity, and C level set below MCL.

Conclusion: COSI questionnaire highlights the specific needs of the CI user referring to the advantages of the CI in those situations. High microphone sensitivity settings might make low-level sounds more audible. C level might need to be reduced to an acceptable level. Based on our results, high microphone sensitivity and setting of C level below MCL should be taken into consideration.

Keywords: Cochlear Implant; Input Dynamic Range; COSI; Sound

Introduction

It is evident that severe to profound hearing impairment can be successfully treated with electrical stimulation of the inner ear using cochlear implants (CI) [1]. CI consists of an implantable part - an electrode array and electronic circuit- and an external part-a speech processor-transforming the acoustic signal into an electric one and stimulating the auditory nerve through the electrodes [2]. For various input levels in different listening environments, the speech processor should provide both audibility and comfort [3].

The range of acoustic input levels that are mapped onto the CI user's electrical dynamic range is known as input dynamic range (IDR) while the difference between threshold and maximum comfortable level (T and C levels) is referred to as electric dynamic range (EDR). The IDR should be wider than 30 dB for optimal speech recognition [4].

The best setting for the individual have to be determined over several sessions. There is wide individual difference in threshold

(T) and comfort (C) levels for electrical stimulation, and preferred microphone sensitivity (MS), volume control, and noise-reduction settings [4].

The client oriented scale of improvement (COSI) questionnaire is a measure of benefit from a rehabilitating device i.e. hearing aid (HA)/CI. The patient determines particular listening situations where hearing ability improvement is needed. It has an open format, which allows the patient to choose the greatest difficult situations [5].

Materials and Methods

Subjects

The study was designed as a cross-sectional study. The study was approved by the Research Ethical Committee and Otorhinolaryngology department of Faculty of Medicine, Cairo University. An informed consent was assigned by all subjects for participation in the study.

Fourteen postlingual cochlear implant adult patients who were implanted and used their device for at least 6 months were collected from Cochlear Implant Unit, Otorhinolaryngology Department, Kasr Al-Ainy University Hospital.

Inclusion criteria:

- Postlingual adult cochlear implant patients using their devices for at least 6 months.

Exclusion criteria:

- Pre and postlingual pediatric cochlear implant patients.
- Age extreme > 60 years.
- Recently implanted cochlear implant subjects.

Equipment:

- Laptop HP: Maestro system software, version 4.0 using Max processor for patients using MED-ELSonata i.
- Laptop HP: Custom Sound system, version 4.2 using portable programming setting (pps) for patients using Cochlear Nucleus.

Test material:

- The COSI questionnaire.

Methods

Nine subjects participated in the study used MED-EL Sonata i-Opus 2 sound processor. Programs were adjusted for four input sensitivity settings as follows:

- The initial setting (default setting):
  - Default threshold (T) level: 10% of the most comfortable level (MCL)
  - The comfort (C) level: MCL
  - Microphone sensitivity (MS): 75%
  - Volume sensitivity: 75%.
- The second setting (behavioral setting):
  - T level: Manual setting.
- The third setting (maximum microphone sensitivity):
  - MS: 100%.
- The fourth setting (reduced C level):
  - C level: Set to 3 steps below the maximum MCL

Four patients used cochlear nucleus with sprint sound processor with four input sensitivity settings as follows:

- 1st default setting:
  - Measured T and C levels already used by the patients
  - Volume sensitivity: 9
  - MS: 9.
- 2nd behavioral setting:
  - T level: set to 5 steps above the lowest heard signal.
- 3rd setting with maximum microphone sensitivity:
  - MS: 12.
- 4th setting with reduced C level:
  - C level: set to 5 steps below the default C level.

One patient was using Esprit 3G sound processor with only three settings as follows:

- 1st default setting:
  - Default T & C levels (used by the patient previously).
- 2nd behavioral setting:
  - T level: set to 5 steps above the lowest heard signal.
- 3rd setting with reduced C level:
  - C level: set to 5 steps below the default C level.

COSI questionnaire

Each program was assessed after 2 weeks using the COSI questionnaire [shown in the appendix]. Subjects compared the four settings regarding different listening situations. The patients identify five specific situations in which hearing ability needs to be improved via rehabilitating devices. These situations can be listening-related, emotional or social. They are categorized into one of 16 standard categories [6]. It is applied into two phases.

First, the patient identifies difficult situations that need to be improved by a new rehabilitating device. Second, after HA/CI fitting, the patient records hearing function change for the identified situations. This change ranges from "worse" to "much better" in addition to giving a numerical score [7].

The responses were given the numbers from 1 to 5, with 1 corresponding to "worse" and 5 corresponding to "much better". Then, the average improvement across all of the listening situations was calculated as average = $\frac{\Sigma x}{n}$ where Σ = sum and n = number of situations [8].

In another scaling method, the patient notes his/her final hearing ability as a percentage score [7]. The questionnaire was administered after 2 weeks of use of each program setting.

Statistical analysis

Data were collected, revised, coded and entered to the Statisti- cal Package for Social Science (IBM SPSS) version 20. The qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges when parametric distribution while non-parametric distribution were presented as median with interquartile range (IQR).

Comparison between more than two paired groups regarding quantitative data with parametric distribution was done by using Repeated Measures ANOVA while non-parametric distribution was done by using Friedman test.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

P > 0.05: Non-significant.

P < 0.05: Significant.

Results and Discussion

Eight of the subjects under study were females and six were males, with a mean age of 31.64 years ranging from 18 to 54 years. The median of hearing loss duration was 7.5 years with IQR 5 - 17 years ranging from 0.6 to 27 years. The median of age at implantation was 25.5 years with IQR 17 - 34 years ranging from 7 to 53 years. The median of duration of device use was 2.9 years with IQR 1.5 - 8 years ranging from 0.6 to 17 years.

The commonest specific needs in the patient population were firstly to hear conversation with group in noise, secondly to hear conversation with 1 or 2 in noise and finally to hear conversation with group in quiet (Figure 1).

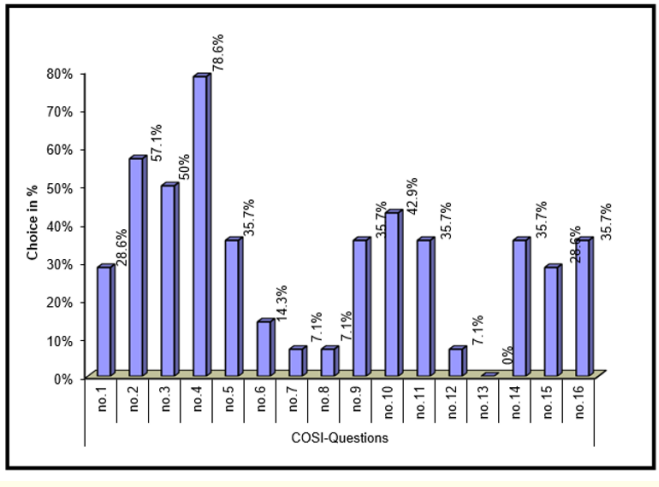


Figure 1: Commonest specific needs (COSI). The most specific needs in the patient population were firstly to hear conversation with group in noise (4), secondly to hear conversation with 1 or 2 in noise (2) and finally to hear conversation with group in quiet (3).

COSI- Questions

1) Conversation with 1 or 2 in quiet; 2) Conversation with 1 or 2 in noise; 3) Conversation with group in quiet; 4) Conversation with group in noise; 5) Television/Radio @ normal volume; 6) Familiar speaker on phone; 7) Unfamiliar speaker on phone; 8) Hearing phone ring from another room; 9) Hear front door bell or knock; 10) Hear traffic; 11) Increased social contact; 12) Feel embarrassed or stupid; 13) Feeling left out; 14) Feeling upset or angry; 15) Church or meeting; 16) others.

Table 1 and figure 2 revealed statistically non-significant difference between the four fittings regarding degree of change in COSI questionnaire.

Table 2 and figures 3 and 4 revealed statistically significant difference between the four fittings regarding final hearing ability at both 2nd and 3rd important listening situations.

Scoring of degree of change in different listening situations No. = 14		1st fitting	2nd fitting	3rd fitting	4th fitting	Repeated measures ANOVA	
		No. = 14	No. = 13	No. = 14	F	P-value	
1st	Mean ± SD	2.43 ± 1.55	2.5 ± 0.76	2.77 ± 1.42	2.43 ± 1.09	0.351	0.704
	Range	1 - 5	1 - 4	1 - 5	1 - 4		
2nd	Mean ± SD	2.36 ± 1.45	2.57 ± 0.85	2.85 ± 1.34	2.29 ± 0.91	0.904	0.409
	Range	1 - 4	1 - 4	1 - 5	1 - 4		
3rd	Mean ± SD	2.29 ± 1.38	2.5 ± 0.76	2.92 ± 1.38	2.43 ± 1.02	0.876	0.414
	Range	1 - 4	1 - 4	1 - 5	1 - 4		
4th	Mean ± SD	2.43 ± 1.45	2.36 ± 0.74	2.62 ± 1.39	2.57 ± 0.94	0.194	0.812
	Range	1 - 5	1 - 4	1 - 5	1 - 4		
5th	Mean ± SD	2.29 ± 1.33	2.5 ± 0.85	2.69 ± 1.32	2.07 ± 0.83	1.025	0.367
	Range	1 - 4	2 - 5	1 - 5	1 - 4		
Average1	Mean ± SD	2.36 ± 1.38	2.49 ± 0.69	2.77 ± 1.32	2.36 ± 0.88	0.552	0.557
	Range	1 - 4	1.2 - 3.6	1 - 5	1 - 4		

Table 1: Degree of change- COSI in different listening situations.

N.B. Listening situations were arranged according to the importance for each patient.

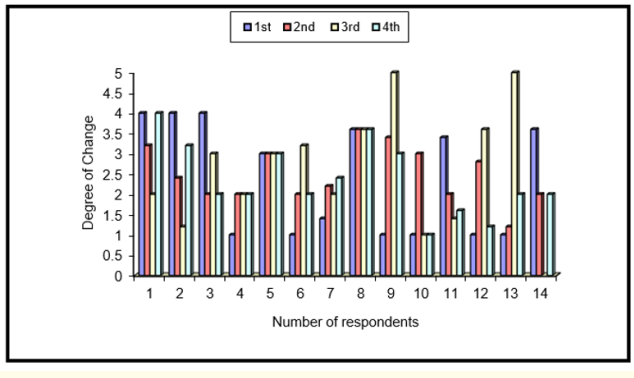


Figure 2: Degree of change- COSI in different listening situations.

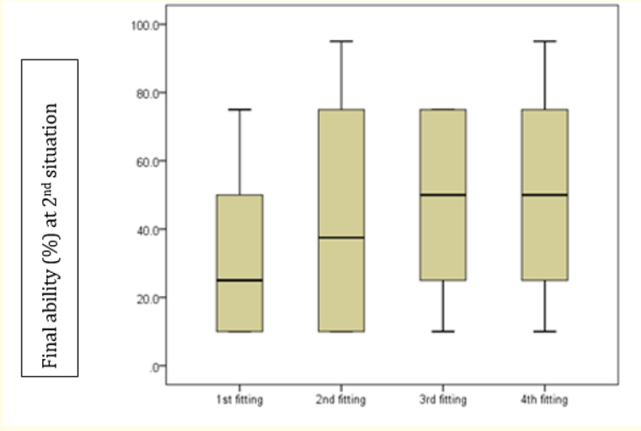


Figure 3: Final ability (%) at the 2nd important situation at each fitting.

Discussion

With the increasing numbers of cochlear implant (CI) users, guidelines for optimal patient benefit from a CI are indispensable for both audiologists and CI users [9]. It is evident that most noisy environments are the real challenge that CI users meet in their daily life regardless of performance at a comfortable listening level [10].

Final ability (%) in different situations No. = 14		1st fitting	2nd fitting	3rd fitting	4th fitting	Friedman test	
		No. = 14	No. = 13	No. = 14	X^2	P-value	
1st	Median (IQR)	25 (10 - 50)	25 (25 - 50)	25 (25 - 75)	37.5 (25 - 75)	0.984	0.365
	Range	10 - 75	10 - 75	10 - 75	10 - 75		
2nd	Median (IQR)	25 (10 - 50)	37.5 (10 - 75)	50 (25 - 75)	50 (25 - 75)	4.171	0.035*
	Range	10 - 75	10 - 95	10 - 75	10 - 95		
3rd	Median (IQR)	25 (10 - 50)	25 (10 - 75)	50 (25 - 50)	50 (25 - 75)	4.224	0.032*
	Range	10 - 75	5 - 75	10 - 75	25 - 95		
4th	Median (IQR)	17.5 (10 - 75)	10 (10 - 75)	25 (10 - 75)	25 (10 - 75)	1.371	0.270
	Range	10 - 75	10 - 75	10 - 95	10 - 95		
5th	Median (IQR)	37.5 (10 - 50)	50 (25 - 75)	50 (25 - 75)	37.5 (25 - 75)	0.870	0.398
	Range	10 - 95	10 - 95	10 - 95	10 - 95		
Average2	Median (IQR)	32.5 (13 - 44)	35.5 (18 - 60)	37 (24 - 65)	36(24 - 65)	2.713	0.104
	Range	10 - 74	13 - 79	13 - 83	18 - 91		

Table 2: Final ability (%) with cochlear implant- COSI in different listening situations.

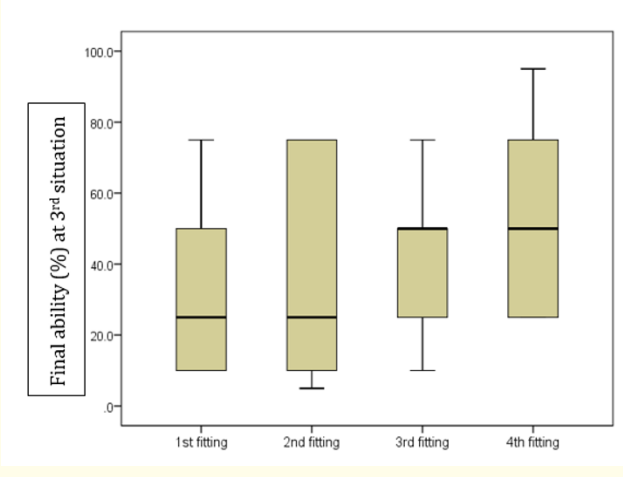


Figure 4: Final ability (%) at the 3rd important situation at each fitting.

Understanding soft speech and listening to individuals speaking from another room are also challenging. Clinical fitting should optimize CI users' ability to understand both soft speech and speech in noise [9].

It is sophisticated to compare results across studies due to differences of signal processing among devices as well as procedural differences. These differences are usually overlooked to allow a suitable comparison of outcomes of variant studies.

Concerning COSI questionnaire, figure 1 shows the most specific needs in our patient population were firstly to hear conversation with group in noise (78.6%), secondly to hear conversation with 1 or 2 in noise (57.1%) and finally to hear conversation with group in quiet (50%).

Contrary to our results, some authors found that the most important specific situations were communication with family members (72%) followed by hearing traffic and listening to the radio. There was equal response for increased social contact and for hearing the doorbell (45%) [7].

Table 2 and figures 3 and 4 showed statistically significant difference between the four fittings regarding the final ability with cochlear implant at both 2nd and 3rd important situations. Both 3rd and 4th programs revealed the highest percentage. This means that the patients preferred the programs with the maximum microphone sensitivity, and C level set below MCL.

Similar to our results, in the study done by James., *et al.* [2], one subject preferred the increased input sensitivity. Furthermore, three subjects mentioned that high microphone sensitivity was useful. The authors stated that C level might need to be reduced to

an acceptable level as was done for a setting of high microphone sensitivity in their study.

Conclusion

- Hearing in noise and listening to multi-talkers are challenging for CI users regardless of their performance at a comfortable level.
- COSI questionnaire highlights the specific needs of the CI user referring to the advantages of the CI in those situations.
- High microphone sensitivity settings might make low-level sounds more audible.
- C level might need to be reduced to an acceptable level.

Recommendation

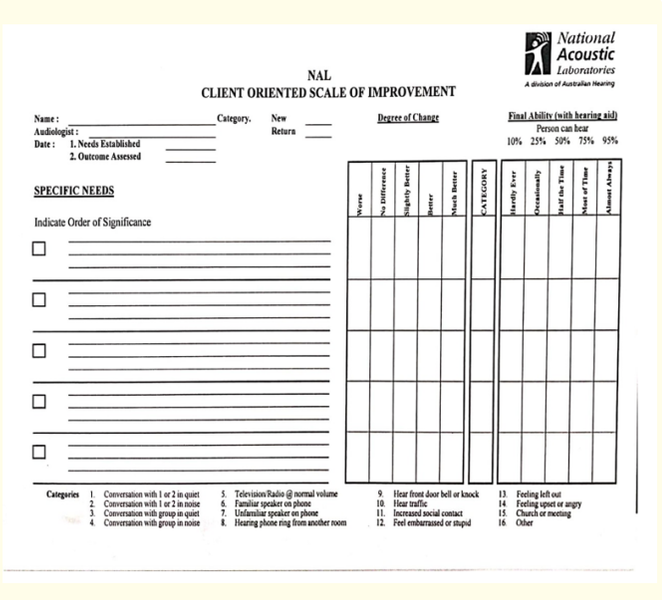
Based on our results, we recommend the following:

1. Using objective methods for further assessment of the effect of change in different input dynamic range variables to correlate with COSI questionnaire results.
2. Further studies for assessment of the effect of change in different characteristics of input dynamic range on a larger sample of patients.
3. Future studies for evaluation of the effect of change of input dynamic range on cochlear performance in CI children.
4. High microphone sensitivity and setting of C level below MCL should be taken into consideration.

Conflict of Interest

No any conflict of interest exists.

Appendix



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NAL
CLIENT ORIENTED SCALE OF IMPROVEMENT

Name : _____ Category. New ____
Audiologist : _____ Return ____
Date : 1. Needs Established _____
2. Outcome Assessed _____

Degree of Change: Worse | No Difference | Slightly Better | Better | Much Better | CATEGORY

Final Ability (with hearing aid): Person can hear 10% 25% 50% 75% 95%: Hardly Ever | Occasionally | Half the Time | Most of Time | Almost Always

SPECIFIC NEEDS

Indicate Order of Significance

Categories
1. Conversation with 1 or 2 in quiet
2. Conversation with 1 or 2 in noise
3. Conversation with group in quiet
4. Conversation with group in noise
5. Television/Radio @ normal volume
6. Familiar speaker on phone
7. Unfamiliar speaker on phone
8. Hearing phone ring from another room
9. Hear front door bell or knock
10. Hear traffic
11. Increased social contact
12. Feel embarrassed or stupid
13. Feeling left out
14. Feeling upset or angry
15. Church or meeting
16. Other

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