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Assessment of the benefits of the Naída CI Q70 and its Ultrazoom strategy for speech recognition in reverberating and noisy listening conditions

Avaliação do Naída CI Q70 e estratégia UltraZoom para o reconhecimento de fala em situações reverberantes e com ruído competitivo

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Abstract

Purpose: 1) To measure speech understanding in noise with the Naída Q70 in the omnidirectional microphone mode (T-Mic) and adaptive directional microphone mode (UltraZoom) in reverberating acoustics and noisy conditions. 2) To measure improvement in speech understanding with use of the Advanced Bionics (AB) Naída Q70 sound processor for existing Harmony users. **Methods:** Seven adult unilateral cochlear implant (CI) recipients, who were experienced users of the Harmony sound processor, participated in the study. Sentence recognition was evaluated in quiet in a reverberating room, with Harmony and Naída CI Q70 processors. Effectiveness of Naída CI Q70's UltraZoom directional microphone was evaluated in noise. Target stimuli were recorded Portuguese sentences presented from 0° azimuth. Twenty-talker babble was presented at +5dB SNR from ±90° azimuth. In addition to sentence recognition, the participants also rated the clarity of sound and difficulty of listening in the various test conditions. In order to evaluate the outcomes under more realistic acoustic conditions, tests were conducted in a non-sound treated reverberant room (RT60 of 553 ms and noise floor of 42.7 dBA (Leq). **Results:** The average sentence recognition in quiet in the reverberant non-sound treated room was 38.5% with the Harmony and 66.5% with Naída CI Q70. The average sentence recognition score in noise was 40.5% with Naída CI Q70 without UltraZoom and 64.5% with UltraZoom. For subjective ratings of sound clarity and listening ease in noise no difference were identified between the test conditions. **Conclusion:** For experienced users of the Harmony sound processor, speech understanding in quiet in a reverberating room was significantly improved with the Naída CI Q70. The use of an adaptive directional microphone technology (UltraZoom) enhanced speech perception in noise.

Keywords: Cochlear implants; Speech perception; Directional microphone technology; Reverberation; Noise

Resumo

Objetivo: Identificar a contribuição do microfone omnidirecional (T-Mic) e microfone direcional adaptativo (UltraZoom) do processador de som Naída CIQ70 para o reconhecimento da fala no ruído e em ambiente reverberante. Identificar a contribuição do processador de som Naída CIQ70 para usuários do processador Harmony. **Métodos:** Participaram do estudo sete adultos com implante coclear unilateral, usuários do processador de som Harmony. O reconhecimento de sentenças foi avaliado em silêncio em sala reverberante (RT60 de 553 ms) e ruído de 42,7 dBA (Leq), com os processadores Harmony e Naída CIQ70. A contribuição do microfone direcional UltraZoom foi avaliada no ruído. As sentenças gravadas foram apresentadas a 0° azimute. O ruído (babble noise) foi apresentado a + 5dB SNR a 90° azimute. Os participantes avaliaram subjetivamente a clareza do som e a dificuldade de escutar nas várias condições do teste. **Resultados:** A média do reconhecimento de sentenças no silêncio com reverberação foi de 38,5% com o Harmony e 66,5% com o Naída CIQ70. A pontuação média de reconhecimento de sentenças no ruído foi de 40,5% com o Naída CIQ70 sem UltraZoom e de 64,5% com UltraZoom. Nas classificações subjetivas de clareza do som e facilidade de escuta no ruído, nenhuma diferença foi identificada entre as condições de teste. **Conclusão:** Para usuários experientes do processador de som Harmony, a compreensão da fala em silêncio em uma sala reverbente foi significativamente melhor com o Naída CIQ70. O uso de uma tecnologia de microfone direcional adaptativa (UltraZoom) contribuiu para o reconhecimento de fala no ruído.

Palavras-chave: Implante coclear; Reconhecimento de fala; Tecnologias de microfone directional; Reverberação, Ruído

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INTRODUCTION

While considerable variability in speech perception abilities exists for cochlear implant users, many listeners can achieve high levels of speech understanding in quiet[(1)(2)]. This level of performance, however, declines significantly in challenging listening environments. Difficulty understanding speech in the presence of competing noise remains one of the greatest struggles for cochlear implant recipients[(3)]. Even at favorable signal-to-noise ratios (SNRs).

Acoustic reverberation such as in large rooms and/or rooms with hard surfaces has been shown to have a detrimental effect on speech intelligibility, especially for cochlear implant users[(4)]. Speech is the first to be degraded by reverberation and the combination with noise can worsen the performance of word recognition by the implanted patient[(5)]. Reverberation is an acoustic phenomenon present in many environments. It occurs when some waves of acoustic energy are reflected and reach the ear after waves that have traveled through a direct path. This effect is caused by speech signal distortion by the blurring of spectral and temporal information[(6-9)]. Nabelek et al. (1989) described the effects of reverberation as a distortion that occurs within each reverberating phoneme and when acoustic information from previous phonemes spreads to subsequent speech components.

For this reason, speech understanding, as measured in a soundbooth or sound treated room, may not accurately reflect the communication difficulties experienced by cochlear implant users in their everyday listening environments. To obtain real measures of the cochlear implant patient's difficulties it is necessary to evaluate speech recognition performance in an environment with concomitant reverberation and noise.

Directional microphones are among the technologies that may help hearing devices users in noisy situations. However, the effectiveness of directional microphones decreases as the number of noise sources of the acoustic environment increases and becomes more diffuse[(10,11)]. Processor technology has been developing rapidly to address and help patients in these situations. Not only implanted users but users of hearing aids can benefit the technology of noise cancelling signal processing[(12,13)] and directional microphones or beamformers that have been shown a significantly improve speech understanding in cochlear implant recipients[(11,14-17)].

The objectives of the present study were to evaluate the contribution of the Ultrazoom over the T-Mic in a noisy and reverberating calibrated room. In addition, to identify the contribution of the upgrade of the speech processor.

METHODS

This prospective study was approved by the Ethics Committee at Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo, under protocol number 1.053.402 (CAAE 43321515.6.0000.0068). Written informed consent was obtained from all subjects before any study-specific tests or procedures were performed. Seven cochlear implant adults, with post-lingual severe to profound bilateral deafness, implanted with Advanced Bionics HiRes 90K device with at least 6 months of experience and open set sentence recognition scores of ≥ 50% in quiet (as measured in a sound booth) participated in the study.

All subjects were Harmony processor users (with T-mic and medium Clear Voice activated) and they were offered to upgrade to Naida CI Q70. The first program of Naida Q70 was the same fitting map in-use of Harmony. Subjects' demographic details are listed in Table 1.

Test setup: Were conducted in a non-sound treated room (reverberation room – RR) with an average reverberation time of 553 ms (RT60) and average noise floor of 42.7 dBA (Leq). The physical dimensions of the room were 3.7m x 3.98m x 2.10 m (width x length x height). Stimuli were presented via Profire loudspeakers placed 1.2 meters away from the listener at 0˚, +90° and -90° azimuth. The speech signal was presented from 0° while the noise was presented from ±90°. Signals were amplified (Profire M-Audio 2626) and then presented via a RME Fireface 800 D/A converter.

Stimuli: Target stimuli were lists of 10 sentences each, recorded in Portuguese[(18)]. Sentences were presented from 0˚ at 65 dB SPL and competing 20-talker babble[(19)] presented from ±90° at +5 dB SNR.

Test conditions: As displayed in Figure 1, to evaluate the contribution of the processor upgrade in a reverberating environment alone, sentence recognition was measured in quiet with parameters of the subjects' fitting map in-use with both Harmony and Naída CI Q70 with T-mic. In order to evaluate the contribution of UltraZoom (UZ), sentence recognition in noise was tested with the Naída CI Q 70 with T-mic and with UZ with the same fitting map. All tests conditions were assessed in a single session in a randomized order, although not blinded, as processors and programs were changed manually.

After each test condition, the participants rated the clarity of sound and difficulty of listening in the various test conditions (Figure 2). These judgments were made in the test room, after each sentence list was completed.

Table 1. Subjects' demographic data

Subject ID	Age (years)	Deafness duration (years)	Time of CI use (months)	Etiology	Speech recognition in quiet in sound booth (%)
1	31	15	84	unknown	80
2	58	10	24	unknown	90
3	47	15	36	unknown	50
4	57	8	24	unknown	50
5	52	12	12	infectious	50
6	48	7	24	unknown	80
7	41	10	60	ototoxicity	90

Subtitle: ID = Subject ID; CI = cochlear implants; % = percentual

Statistical analysis

The comparison of Harmony and Naida CI Q70 sentence recognition was done through descriptive analytical measures and Mann Whitney test considering significance when $p < 0.05$.

RESULTS

The average performance with the Harmony processor in the RR (Table 2) was significantly reduced as compared to that measured previously in a sound booth (Table 1). Figure 3 and

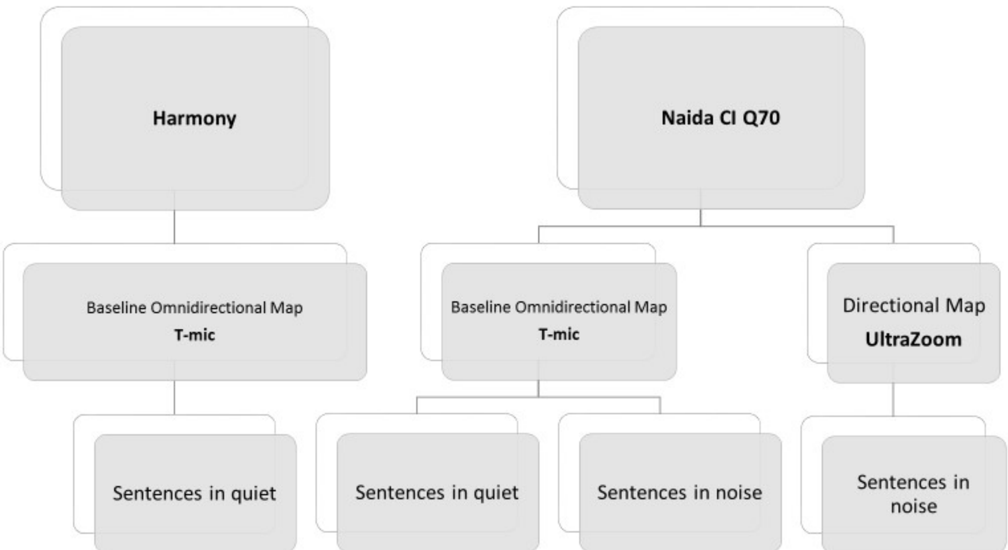

Figure 1. Test conditions used in the study

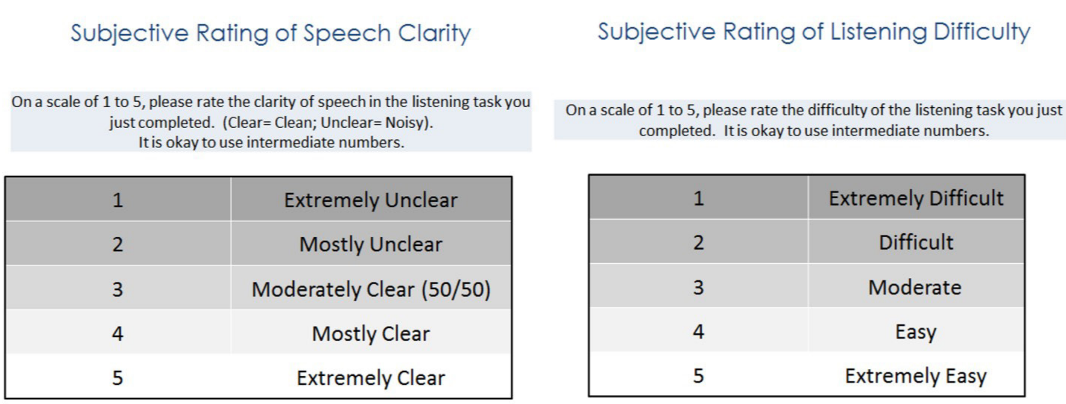

Figure 2. Visual analogue scales for clarity of sound and difficulty of listening

Table 2. Results of sentence recognition in quiet (%), the clarity of sound and ease of listening judgement, comparing Harmony and Naida CI Q70 and in noise comparing Naida CI Q70 with T-Mic and UltraZoom (UZ)

	Harmony	Naida CI Q70	p
Sentence recognition in quiet (%)	38.5	66.5	**0.0368**
Clarity	4	4	0.2031
Ease of listening	3	3	0.2411
	Naida CIQ70 T-mic	**Naida CIQ70 UZ**	
Sentence recognition in noise (%)	40.5	64.5	0.0626
Clarity	3	3	0.3507
Ease of listening	2	3	0.3046

Subtitle: % = percentual

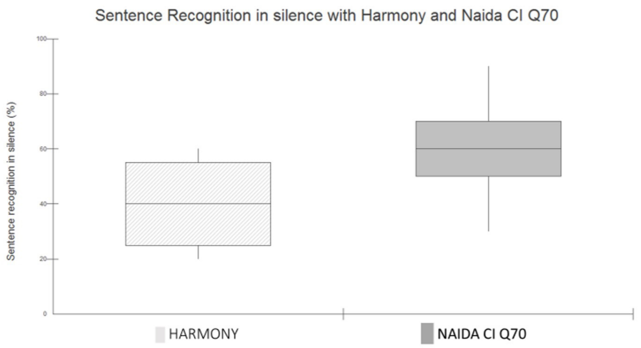

Figure 3. Median sentence recognition scores in quiet with the Harmony processor and with the Naída CI Q70 processor in the reverberant room (RR)

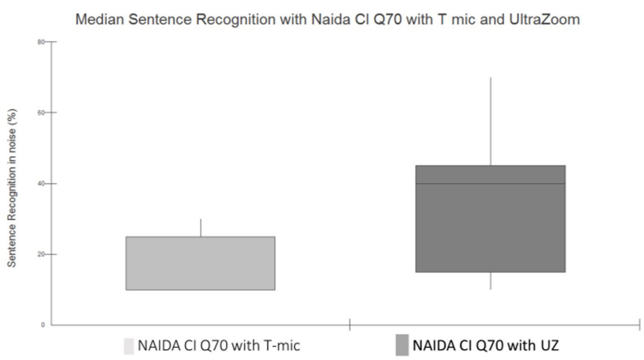

Figure 4. Median sentence recognition scores in noise with the Naída CI Q70 processor with T-Mic and UltraZoom in the reverberant room (RR)

Figure 4 show that sentence recognition scores were significantly higher with Naída CI Q70 than Harmony ($p<0.05$) in quiet and in noise with Ultrazoom. Subjective ratings showed similar sound clarity with the Naída CI Q70 processor (Table 2).

DISCUSSION

The study shows that experienced users with the Harmony processor can benefit from new technology soon after being fitted with the Naída CI Q70[20]. While the Harmony speech processor utilizes T-Mic and ClearVoice, it does not have the capability to use the beamforming technology of the Naída CI Q70[21]. Also, speech recognition scores in quiet were higher with the Naída CI Q70 than with the Harmony, despite the challenge of the reverberating environment. One may also infer that despite our concern in troubleshooting the Harmony speech processor, any unrecognizable deterioration due to years of constant use might have influenced the results.

Ratings of speech clarity in noise while using UltraZoom and ClearVoice were nearly equivalent to those in quiet, suggesting there may be a qualitative benefit for listeners utilizing these strategies in their everyday listening program.

Despite there was no statistical difference between the sentence recognition scores with T-Mic and Ultrazoom in the Naida CI Q70, probably due to the small sample size, the median score was higher with the UZ. In fact, Geissler et al. (2014), Buechner et al. (2014) and Dorman et al. (2017) also found better results with the use of UltraZoom strategy in comparison to Harmony or the Naída CI Q70 with T-Mic only.

Lastly, this study demonstrates the impact of challenging room acoustics, such as reverberation, on speech understanding in CI recipients, even in absence of noise. Sentence recognition scores in quiet were worse in the reverberant room than those previously obtained in the sound booth (table 1), mirroring the difficulty reported by patients in their daily life.

CONCLUSION

Naída CI Q70 offers better speech understanding and clarity in quiet for experienced users of the Harmony sound processor. Beamforming technology like UltraZoom strategy facilitate speech perception in noise, even in reverberant environments.

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