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Original article

Rehabilitation of telephone communication in cochlear-implanted adults

S. Borel[a,b,*], S. Dupré[c], M. de Bergh[a,b], O. Sterkers[a,b], I. Mosnier[a,b], E. Ferrary[a,b]

[a] APHP6, Centre référent implant cochléaire et du tronc cérébral adulte d'Ile de France, unité fonctionnelle implants auditifs et explorations audio-vestibulaires, service ORL, GH Pitié-Salpêtrière, Paris, France
[b] Sorbonne Université, Inserm, Réhabilitation Chirurgicale Mini-invasive et Robotisée de l'Audition, Paris, France
[c] Sorbonne Université, Département Universitaire d'Enseignement et de Formation en Orthophonie, Paris, France

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ABSTRACT

Objectives: Telephone use correlates with quality of life, and is one of the most important expectations of cochlear implant candidates. The aim of the present study was to assess the benefit of a progressive intensive 18-session training program, conducted by telephone in cochlear implant recipients.
Material and methods: Nine cochlear-implanted adults underwent telerehabilitation focused on telephone use, with before-and-after assessment of: auditory performance, on Lafon monosyllabic words and MBAA sentences in quiet, cocktail-party noise and by phone; telephone use, on ad-hoc surveys and number of calls per week; and quality of life on ERSA and APHAB questionnaires.
Results: Before training, monosyllabic word comprehension was poorer by telephone than by direct voice ($64 \pm 5.7\%$ vs. $26 \pm 5.3\%$; $P < 0.05$). After the 6-week training, there was improvement in the "note taking" telephone message task (85.0 ± 3.7 vs. 50.0 ± 9.0 out of 100; $P < 0.001$), daily phone use (57.0 ± 4.3 vs. 29 ± 5.4 out of 100; $P < 0.0001$), and number of calls in the week before assessment (0.0 ± 0.0 vs. 11.0 ± 3.0; $P < 0.0001$).
Conclusions: A progressive intensive training program by telephone improved phone use in the daily life of cochlear-implanted adults.

1. Introduction

Phone use is an important factor in quality of life for cochlear implant users [1] and affects the subjective success of rehabilitation (2012 CISIC association on-line survey: *www.cisic.fr*). The difficulties come from the lack of visual input, monaural comprehension, and a telephone signal often limited to the 300-3,400 Hz frequency band [2], with deformation, echoes and parasite noise. Moreover, stress and worry over phone use can be inhibiting. All in all, cochlear implant bearers have often ceased using the phone at all for some years, discouraged by failure and embarrassing situations of mutual incomprehension, even if they otherwise take full advantage of their implant.

Depending on the report, between two-thirds and more than 80% of cochlear-implanted adults use the phone, and age is not a negative factor [3–9]. These figures, however, are difficult to compare, as methodologies differed. Some studies were based on interview, asking whether the phone could be used just for set conversations with a familiar speaker on a predefined subject, or for free conversations undetermined in advance with unknown speaker. To be able to follow a simple telephone conversation, it seems necessary to have at least 50% comprehension of sentences in silence using only the implant, without lip-reading, [10,11]. Wireless accessories improve speech comprehension on the telephone [12,13]. And female implant users seem to be more at ease on the phone than males [3–6].

Specific types of training have been developed to improve phone use [14–16], but none as yet exist in French. Moreover, they have always been implemented within a health-care setting, rather than remotely, as in real life.

Since 2010, telemedicine has greatly developed in audiology and speech therapy [17,18]. Telerehabilitation of cochlear implant bearers, however, has not yet been strongly developed and, in France, lacks any specific framework.

The aim of the present study was to assess the benefit of a progressive intensive 18-week telephone communication training program conducted by phone, with the patient at home or in the workplace.

* Corresponding author at: Unité Fonctionnelle Implants Auditifs et explorations audio-vestibulaires, Centre maladies rares surdités génétiques de l'adulte and neurofibromatose de type 2, groupe hospitalier Pitié-Salpêtrière, 50–52, boulevard Vincent-Auriol, 75013 Paris, France.
E-mail address: borel.steph@gmail.com (S. Borel).

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2. Materials and methods

A retrospective study was conducted in the framework of follow-up of cochlear implanted patients in a reference center. Patients provided written consent for the use of their data (CNIL data protection commission n°2050850).

2.1. Patients

Nine patients (8 female, 1 male) with post-lingual hearing loss, aged 71 ± 3.7 years (median, 75 years; range, 46–82 years), were included. They took a specific telephone communication training program as part of their post-implantation management. The program was offered to patients who did not use their implant to phone, with ≥ 50% sentence comprehension on the Marginal Benefit of Acoustic Amplification (MBAA) test, in silence (implant only, direct voice at conversational intensity). All were native French speakers, without known cognitive, neurologic or sensory impairment (apart from hearing loss). To enable rapid feedback on any problems during the training sessions, patients could be contacted directly (e-mail, text message or telephone via the contralateral implant) or via a family member or workmate. Hearing loss duration was 26 ± 3.9 months (range, 12–44 months). Four patients used a CP810 processor (Cochlear Ltd™, Sidney, Australia), 3 an Opus 2 (Med-El GmbH™, Innsbruck, Austria) and 2 a Naida (Advanced Bionics™, Stäfa, Switzerland). Only 1 woman was working, the others being retired. Etiology was known in 4 cases: otospongiosis (n = 2), chronic otitis media (n = 1) and Meniere's disease (n = 1). Eight patients had a contralateral hearing aid, which 7 of them could use for phoning. Community speech therapy was complete or suspended in all cases, and had lasted a mean 16 ± 2.53 months (range, 3–26 months). Six had had telephone training with their implant during this speech therapy, ranging from 3–5-min sessions to 20–40-min sessions, but none had transferred these skills to everyday life.

2.2. Rehabilitation program

Two of the center's speech therapists made the assessments and a third conducted the rehabilitation. The 4 assessments were made in the center, while the training sessions were conducted remotely, with the therapist in the hospital and the patient at home or at work. In the first consultation (T1), the principles and procedure of the training program were explained and a first series of tests was performed. In the second consultation (T2) 2 weeks later, the patient's questions were dealt with and a second series of tests was performed. In these two consultations, the patient was shown how to position the phone with respect to the implant microprocessor, the training program was presented, and a 75-page booklet was given as a support, with advice on conducting a telephone conversation. Rehabilitation was then conducted, lasting 6 weeks. A third assessment was made at the end of the program (T3) and a fourth 1 month later (T4).

2.3. Telephone training protocol

The training program comprised 3 sessions a week for 6 weeks, each with 3 exercises. Each week had a dedicated objective: listening confidence on closed lists (week 1); on semi-open lists (week 2); on open lists (week 3); strictly framed telephone conversation (week 4); conversation on a predefined subject (week 5); and, finally, free conversation (week 6). This program is available free of charge for speech therapists to use (TCT-6, license 1Gu4mzqTS6wpZMvAaiMtGBQ7f71sYXaa3 V; http://creativecommons.fr).

During the sessions, the contralateral hearing aid was on, but the phone was held on the implanted side, with no accessories or amplification, so that the contralateral device made no contribution to the communication. Two patients used a landline, 4 a cellphone, and 3 either.

Sessions in the first 3 weeks lasted about 15 minutes, with exercises very like in standard speech therapy but transposed to the phone. The booklet helped the patient follow what the therapist was saying and easily find the instructions for each exercise. The aim was to restore the patient's self-confidence, gradually letting go of the support, while developing a reflex over the sessions of holding the phone as close as possible to the microprocessor. The next 3 weeks aimed to progressively develop conversation on the phone through dialogues. Session duration progressively increased, up to 25 minutes, as exercises were less and less standardized, more open, and adapted to individual imagination and ease of communication. Each session was followed by debriefing on any problems encountered, by e-mail or text message, or by phone, using the contralateral aid at first then via the implant for the last sessions; if necessary, a family member or workmate provided the feedback.

2.4. Auditory performance assessment and telephone note-taking

Assessment was conducted in an audiometry booth. The contralateral hearing aid, if any, was switched off and replaced by an ear-plug so that only the implant would be tested. Tests were run first in silence, using 17 three-phoneme words (Lafon cochlear lists), and 15 MBAA sentences, under 3 conditions: direct voice; phone; and a recording calibrated at 65 dB SPL by an audiometer, delivered in free field via speakers. Testing in noise then used 15 MBAA sentences recorded at 65 dB SPL with cocktail-party noise for a signal-to-noise ratio of 5 dB SPL. Finally testing was performed using a telephone; this required a second speech therapist, in a separate room, phoning on an internal hospital line to the patient in the audiometry room, with the main investigating speech therapist. The patient was not familiar with the voice of this second speech therapist. Note-taking consisted in noting down 10 relevant pieces of information in a phone message. Four different messages were used, all with the same structure and length (95–98 words), concerning voluntary-sector actions: bottle-stopper collection, and organizing a sports event, a bar or a clothing sale. Presentation order was randomized. Scoring was performed by an investigator sitting beside the patient, and took account of how often the patient asked the speaker to repeat: 1 point for a note taken on first listening, 0.5 points in case of 1 repetition needed for correct note-taking, and 0 points for information not taken down or requiring more than 1 repetition. Scores were thus 0 to 10.

2.5. Self-assessed everyday phone use

At the time of study, there existed no validated French questionnaire on phone use, and one was therefore drawn up, comprising 4 visual analog scales (Appendix 1). Part A, inspired by Cray et al.'s questionnaire (2004) [4], was drawn up by our team and comprised 20 questions concerning telephone communication situations, with responses ranging from 0 for "impossible" to 5 for "always possible", with a score from 0 to 100; the higher the score, the better the self-assessed use of the phone. Part B assessed self-confidence, on a 0–10 scale. Part C assessed stress using the phone, scored 0–10. Part D collected the number of calls made using the implant during the previous week, and was not applied at the T2 consultation at the beginning of training.

2.6. Self-assessed impact of hearing loss

Impact of hearing loss in various situations was assessed on the APHAB questionnaire [19], comprising 24 questions relating to everyday situations, scored 0% (no problem) to 100% (maximum daily life problem). Impact on communication and quality of life was assessed on the ERSA questionnaire, comprising 20 questions relating to quality of life and personal, social and occupational life, each scored out of 50, for a total 200 for the patient in work or 150 for the 8 retired patients [20]. Both questionnaires were filled out completely.

2.7. Statistics

Descriptive statistics and comparative analysis used XLSTAT software, version 2014.4 (Addinsoft). Data were reported as mean ± SEM [range]. Comparison used the non-parametric Friedman ANOVA for matched samples. In case of effect, post-hoc Nemenyi tests were applied. The significance threshold was set at $P < 0.05$.

3. Results

All patients were enthusiastic and assiduous in their treatment. None encountered difficulties in passing from one weekly step to another.

3.1. Auditory performance

At the first (T1) assessment, a test-administration condition effect (direct voice, recording or phone in silence) emerged (Table 1). On Lafon word comprehension (ANOVA; $P < 0.0005$) was poorer by phone than on direct voice (post-hoc test, $P < 0.001$). For MBAA sentences, the voice in noise was less well understood than the direct voice (post-hoc test, $P < 0.001$) or recorded voice (post-hoc test, $P < 0.01$); understanding over the phone did not significantly differ from the other 3 conditions, including the recorded voice in noise.

During training, between T1 and T4, there was no training effect on Lafon word recognition, whether by phone, recorded or direct voice (Table 1, Fig. 1). In contrast, for MBAA sentences, understanding by phone and with the recorded voice in silence improved (respectively, $P < 0.02$ and $P < 0.001$). Post-hoc tests, however, revealed no significant differences between assessment time-points, probably due to scatter and the small sample size. It may be worth noting that understanding improved between the initial consultation and the 1-month post-training assessment for MBAA sentences by phone (+14 ± 5.2%; range, −13 to +34; median, 13: paired t test, $P < 0.05$) and with the recorded voice in silence (+19 ± 6.7%: range, 0 to +59; median, 13; paired *t*-test, $P < 0.05$). Telephone note-taking improved markedly as of the end

Table 1
Auditory performance.

	1st consultation (T1)	Pre-training (T2)	Post-training (T3)	1 months post-training (T4)
Lafon words (%)	§§§			
Direct voice	64 ± 5.7 [47–100]	52 ± 4.5 [41–82]	54 ± 6.3 [30–94]	54 ± 6.7 [18–82]
Recorded voice in silence Telephone	51 ± 6.1 [29–82]	46 ± 8.4 [6–88]	47 ± 5.4 [18–76]	50 ± 5.9 [24–76]
Direct voice	26 ± 5.3 [0–59]	32 ± 5.4 [0–47]	35 ± 4.3 [18–59]	39 ± 4.6 [18–59]
MBAA sentences (%)	§§§			
Direct voice	81 ± 5.6 [53–100]	79 ± 5.8 [47–100]	87 ± 4.0 [67–100]	89 ± 3.4 [67–100]
Recorded voice in silence***	72 ± 8.0 [34–100]	83 ± 6.0 [47–100]	91 ± 2.8 [80–100]	89 ± 4.0 [67–100]
Telephone*	61 ± 7.0 [33–100]	59 ± 8.7 [7–93]	71 ± 5.2 [47–100]	74 ± 5.9 [40–100]
Recorded voice in noise	24 ± 9.6 [0–93]	26 ± 9.8 [0–87]	24 ± 9.1 [7–93]	24 ± 9.0 [0–86]

Values reported as mean ± SEM [range] for $n = 9$. MBAA: Marginal Benefit of Acoustic Amplification. Administration condition effect at T1: Lafon words (ANOVA§§§: $P < 0.0005$); post-hoc tests: telephone < direct voice ($P < 0.001$); MBAA sentences (ANOVA§§§: $P < 0.0001$); post-hoc tests: recorded voice in noise < direct voice ($p < 0.001$) ∼ recorded voice in silence ($P < 0.01$). Progression (T1, T2, T3, T4): MBAA sentences, recorded voice in silence (ANOVA: ***: $P < 0.001$); MBAA sentences, telephone (ANOVA: *: $P < 0.02$).

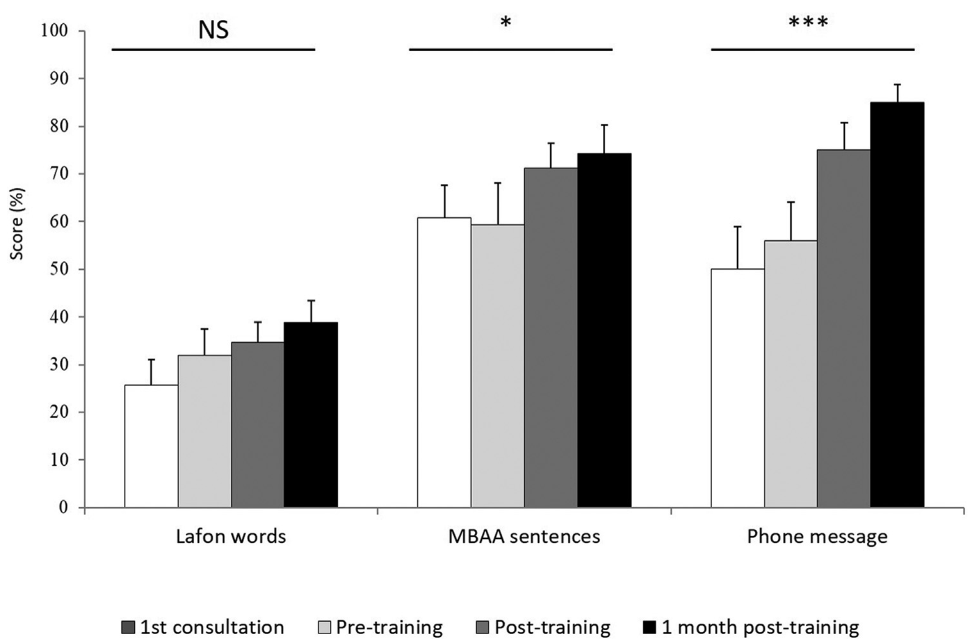

Fig. 1. Comprehension and communication by telephone. Values reported as mean ± SEM for $n = 9$. Results for note-taking of a phone message reported as %. ANOVA: NS: non-significant; *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$.

of training ($P < 0.02$), with improvement maintained at 1 month post-training ($P < 0.0001$) (Fig. 1).

3.2. Self-assessed everyday phone use

Patients reported improvement (Table 2) in phone use in everyday life ($P < 0.0002$). Scores on Part A of the questionnaire almost doubled between the first consultation and the end of training ($P < 0.05$) and maintained this level at 1 month. Self-confidence in using the phone also increased ($P < 0.05$) and was maintained. Stress on hearing the phone ring decreased, although the difference did not achieve significance. Training increased the number of personal or work-related calls sent in daily life ($P < 0.001$) from a mean 0 ± 0 the first consultation to 11 ± 3 at 1 month post-training, although with wide individual variation (Fig. 2). The number of calls increased for 8 of the 9 patients; at last assessment, only 1 patient had made no calls during the previous week, whereas she had made 3 during the week before the end of the training program; she said she had had no need or opportunity to phone during the week.

3.3. Self-assessed impact of hearing loss

Global APHAB score for auditory capacity in various situations improved over time: 60 ± 3.7 at T1, 64 ± 3.8 at T2, 53 ± 3.2 at T3 and 50 ± 5 at T4 ($P < 0.01$). ERSA score was stable: $86/150 \pm 10.1$ at T1, 77 ± 10.3 at T2, 87 ± 10.3 at T3 and 87 ± 9.1 at T4). Results in the Working Life domain for the patient who was in work were 27/50 at T1, 27 at T2, 41 at T3 and 40 at T4.

4. Discussion

The present study showed that adapted telerehabilitation not only improved understanding of sentences over the phone or in a recording but also increased the number of calls made in daily life. However, subjects were not asked whether these calls involved familiar or unfamiliar speakers and contexts. Before training, 8 of the 9 subjects used their contralateral hearing aid to phone–with difficulty. Six had already had telephone training as part of their speech therapy and this had not enabled them to use the phone with their implanted ear. The present training made them aware of their capacity to understand speech over the phone via the implant and enhanced their self-confidence. The particularity of the present program was its intensity, with 3 sessions a week for 6 weeks, and that it was conducted remotely, in real-life conditions. This certainly enhanced skill transfer to everyday life. Moreover, benefit was maintained at 1 month, suggesting that the results may be stable or even that an upward trend is set in motion.

At the initial consultation, speech comprehension of Lafon short 3-phoneme words was more limited over the phone than with direct voice. A fatigue effect cannot be ruled out, as these word lists were always delivered last over the phone. There may, however, be other reasons. The narrow 300–3,400 Hz bandwidth on a landline, compared to 100–8000 Hz on most implant processors, may degrade comprehension over the phone. Several studies reported the negative impact of a restricted bandwidth on speech comprehension in adult cochlear implant users [2,21,22]. Using a cellphone seems to improve comprehension [23], although with great variation according to model. Growing us of the VoIP "Voice over Internet Protocol" by access providers may help comprehension, as the bandwidth is broader, at 100–8000 Hz [24]. Finally, at the various

Table 2
Self-assessed phone use in daily life.

	1st consultation (T1)	Pre-training (T2)	Post-training (T3)	1 months post-training (T4)
A. Phone use (/100)***	29 ± 5.4 [0–47]	38 ± 5.3 [4–56]	57 ± 4.2 [40–76]	57 ± 4.3 [37–82]§§§
B. Self-confidence (/10)**	3 ± 0.6 [1–7]	4 ± 0.5 [2–6]	6 ± 0.7 [3–10]	6 ± 0.7 [4–10]
C. Stress (/10)	6 ± 1.0 [2–10]	6 ± 1.0 [3–10]	5 ± 1.0 [1–8]	4 ± 1.0 [2–8]
D. Number of calls***	0 ± 0 [0–0]	NT	5 ± 1.0 [0–15]	11 ± 3.0 [0–30]§§§

Values reported as mean ± SEM [range] for $n = 9$. NT: not tested. Progression (T1, T2, T3, T4), ANOVA: A (***: $P < 0.001$), B (**: $P < 0.01$) and D (***: $P < 0.001$). Post-hoc tests for T1 vs. T4 significant for A (§§§: $P < 0.001$) and D (§§§: $P < 0.001$).

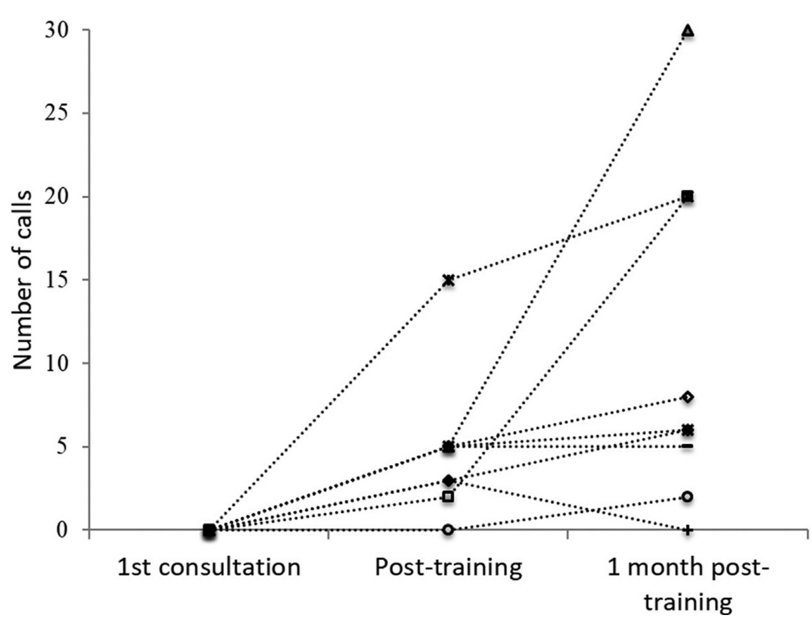

Fig. 2. Number of calls made by each of the 9 patients, using the cochlear implant, in daily life during the week preceding assessment.

assessments, it was seen that phone position with respect to the microprocessor was not always optimal–which can very easily be corrected.

As intended, the training program improved sentence comprehension over the phone; but it also improved comprehension of recorded sentences in silence. This interesting finding may be related to several factors: listening training with an impoverished and deformed telephone signal may have improved understanding of the recorded voice and of complex sounds. In the training program, most exercises detailed in the accompanying booklet used long verbal supports, recruiting some cognitive involvement; few worked on analytic syllable discrimination or short words. This may account for the lack of improvement in comprehension of Lafon words over the phone. Moreover, the intensive training may also have improved understanding of the message as a whole, reinforcing the subject's attention capacity.

Regular phone use helped patients realize that they had recovered the ability to phone, whence the increasing number of calls made in daily life. No previous rehabilitation programs for adult cochlear implant users [14–16] had number of phone-calls in real life as an assessment endpoint. Although using the phone remained stressful, patients felt more at ease and it seems likely that stress decreases over time as positive experiences accumulate.

The decrease in APHAB score indicated improvement in listening quality and overall communication. It is likely that auditory training on an impoverished support such as a telephone signal improves listening capability in other daily life situations apart from telephone conversation.

To improve phone positioning with respect to the microprocessor, patients used the telephone without any listening aid. Such accessories, however, have been shown to improve word repetition [12,13] and could play a useful role in rehabilitating telephone communication.

5. Conclusion

The present training specifically focusing on listening over the phone in real-life conditions improved phone use and self-confidence in daily life. Auditory performance over the phone and with a recorded support increased, and the overall auditory experience improved. Although the study sample was very small, results were encouraging. This training could be offered to all implant users early on in their post-implantation rehabilitation, once their sentence recognition score reaches 50%, so as to enable a larger-scale retrospective study.

Disclosure of Interest

The authors declare that they have no competing interest.

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Annexe 1. Self-administered questionnaire

Part A. How would you assess these telephone situations with the phone on the implant side?

	Impossible	Very difficult	Quite difficult	Quite easy	Easy	Always possible
1. Hearing the ring tone	0	1	2	3	4	5
2. Recognizing the "busy" tone	0	1	2	3	4	5
3. Differentiating tone and voice	0	1	2	3	4	5
4. Differentiating voice and surrounding noise	0	1	2	3	4	5
5. Differentiating male versus female voice	0	1	2	3	4	5
6. Recognizing a familiar voice	0	1	2	3	4	5
7. Understanding a voice-mail message	0	1	2	3	4	5
8. Understanding without asking to repeat	0	1	2	3	4	5
9. Having a conversation on a familiar subject with a familiar person	0	1	2	3	4	5
10. Having a conversation on an unfamiliar subject with a familiar person	0	1	2	3	4	5
11. Starting a phone-call	0	1	2	3	4	5
12. Taking an appointment with a familiar person	0	1	2	3	4	5
13. Having a conversation on a familiar subject with an unfamiliar person	0	1	2	3	4	5
14. Having a conversation on an unfamiliar subject with an unfamiliar person	0	1	2	3	4	5
15. Taking an appointment with a professional (doctor, realty agent)	0	1	2	3	4	5
16. Asking for information about a product or service	0	1	2	3	4	5
17. Negotiating an estimate or pay-rise	0	1	2	3	4	5
18. Having a conversation in a noisy street	0	1	2	3	4	5
19. Being able to attend to another task while on the phone	0	1	2	3	4	5
20. Carrying out a conversation to the end without effort	0	1	2	3	4	5

Part B. Self-confidence

On a scale of 0 to 10, how would you rate your self-confidence using the phone with your cochlear implant?

0: not confident 10: perfectly confident

Part C. Stress

On a scale of 0 to 10, how would you rate your level of stress when the phone rings?

0: no stress at all 10: very high stress

Part D. Number of calls made

How many calls did you make this last week using your implant?

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