Comparison between two perception tests in patients with severe and profoundly severe prelingual sensori-neural deafness

Confronto fra due test percettivi in soggetti con sordità prelinguale neurosensoriale grave e gravissima

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Parole chiave

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Summary

Patients with severe and profoundly severe bilateral sensori-neural prelingual deafness constitute a group of particular interest in the organization of the National Health Service; every patient must, in fact, follow a prosthetic-rehabilitative-educational programme lasting many years and organized under different areas to compensate for his/her communicative difficulties, especially with regard to the speech canal. No reliable data providing details of the efficacy and efficiency of any of these points is available. A critical point in the rehabilitation process is that of auditory perception training. Of the few auditory perception tests presently available in Italian, the following were examined: namely, EARS (Evaluation of Auditory Responses to Speech) battery, on the one hand, and the Italian version of the ESP (Early Speech Perception), GASP (Glendonald Auditory Screening Procedure), NU-CHIPS (Northwestern University Children's Perception of Speech) and WIPI (Word Intelligibility by Picture Identification) tests on the other. A group of 10 patients presenting severe and profoundly severe bilateral sensori-neural prelingual deafness received the two tests at the beginning and after six months of auditory perception rehabilitation. The findings emerging from the two different test sessions were analysed and compared. The EARS battery was seen to have enabled even very early and highly developed stages of auditory perception to be detected in comparison with the other battery, which, however, was more accurate in evaluating the ability to discriminate and identify words on the basis of their spectral characteristics. The Authors propose the combined use of the two test batteries to evaluate the efficacy and efficiency of auditory perception training in patients with severe and profoundly severe bilateral sensori-neural prelingual deafness.

Riassunto

I soggetti con sordità bilaterale neurosensoriale prelinguale grave e gravissima costituiscono un gruppo di interesse per l'organizzazione del sistema sanitario; infatti ogni soggetto deve percorrere un iter protesico-abilitativo-educativo pluriennale articolato in più punti per compensare le difficoltà comunicative specie sul canale uditivo-fonatorio. Per nessuno di questi punti si dispone di dati precisi in termini di efficacia ed efficienza. Un punto critico del percorso abilitativo è rappresentato dall'educazione alla percezione uditiva. Fra i pochi tests di percezione uditiva attualmente disponibili in italiano sono stati considerati la batteria EARS (Evaluation of Auditory Responses to Speech) da una parte e la versione italiana dei tests ESP (Early Speech Perception), GASP (Glendonald Auditory Screening Procedure), NU-CHIPS (Northwestern University Children's Perception of Speech) e WIPI (Word Intelligibility by Picture Identification) dall'altra. Un gruppo di 10 soggetti affetti da sordità bilaterale neurosensoriale prelinguale grave e gravissima è stato sottoposto ai due tests all'inizio e al termine di un periodo di sei mesi di educazione alla percezione uditiva. Vengono analizzati e confrontati i risultati emersi dalle due diverse rilevazioni testistiche. Si è osservato che la batteria EARS permette di rilevare anche stadi molto precoci e molto sviluppati della percezione uditiva rispetto all'altra batteria, che però si dimostra più precisa nella valutazione delle abilità di discriminazione e identificazione di parole in base alle caratteristiche spettrali. Gli autori sostengono la possibilità di utilizzo di entrambe le batterie testistiche per valutazioni di efficacia ed efficienza nella educazione della percezione uditiva nel soggetto con sordità bilaterale neurosensoriale prelinguale grave e gravissima.

Introduction

In the approach to communication, the prevailing interest centres on sensori-neural bilateral deafness with a hearing threshold greater than 65 dB for frequencies of 500 Hz, 1000 Hz and 2000 Hz and an onset prior to three years of age. Patients suffering from this pathological condition are unable to acquire speech and language spontaneously unless they undergo a long rehabilitative-educational process [1 2]. This requires:

1. fitting the patient with a prosthesis, selected from the present options (retroauricular hearing aid, cochlear implant, tactile aids); 2. extremely early and early intervention, organized as follows: a) basic general education, b) specific propedeutic training (comprising speech perception, stomatic skills and praxis, interpersonal relations, visual perception, and manual praxis), c) language education (comprising both a visual/gestual component and an auditory/vocal component); 3. management, in collaboration with other social agencies, of the problems related to compulsory education and the working world [11].

A fundamental aspect of the rehabilitation process, regardless of a prevalent tendency towards oralism or the use of sign language is, therefore, that of auditory perception training; and a fundamental role in this process, is to be assigned to the numerous subcortical centres [6].

The perceptive function of the neural network of the central acoustic pathway depends both on genetic and experiential (personal and cultural) factors, the education of the deaf child is basically centered on these factors [8 12 14].

In the Anglo-Saxon world, the evaluation of auditory perception analyses four points of increasing difficulty: 1) detection, i.e., the presence or absence of sound; 2) discrimination, i.e. ability to establish whether two stimuli are different or the same; 3) identification, recognition of a stimulus amidst a limited number of possible stimuli; 4) recognition, i.e., recognising a stimulus in an open set, without the help of a multiple choice [4]. In Italy, nine parameters have been elaborated to classify speech stimuli: 1) auditory-motor coordination; 2) figure-background separation; 3) timber constancy; 4) silence-sound separation; 5) impulsive-continuous separation; 6) sound-noise separation; 7) pitch dynamics; 8) intensity dynamics; and 9) separation between continuous sound and regularly interrupted continuous sound [9]. Bearing these considerations in mind, it is clear that speech perception is only one aspect of the vaster question of auditory perception.

There are fundamentally two approaches to the evaluation of auditory perception in children affected by severe or profoundly severe deafness who use retroauricular hearing aids, channel vibrators, or cochlear implants. First of all, it is assumed that the child acquires auditory perception skills according to a hierarchical pattern; the tests are, therefore, structured so that every child achieves particular skills according to a particular level, before he/she can proceed to the tests of the following level. Secondly, instead, no a priori assumptions are made as to the sequencing of development in the auditory perception skills, for which children take a one-shot battery of tests to evaluate the range of these skills [5]. While the Evaluation of Speech Perception in the Deaf Child battery [3] follows an approach of the former type, EARS is conceptually organized along the latter lines [1].

Aim of the present investigation was to verify the main differences between the two batteries using Italian-speaking patients in order to obtain data upon which the clinical options in each individual case might be based. A further aim of the study was to demonstrate improvement in a skill following specific rehabilitative intervention over a relatively short period of time.

Patients and Methods

Subjects

Ten children (6 boys, 4 girls, age range 2.5-8.11 years) were included in the study. All presented severe or profoundly severe bilateral sensori-neural deafness, the onset of which was prior to 36 months of age. All were fitted with conventional retroauricular hearing aids. Of these children, 4 presenting general performance retardation, were, nonetheless, included in the study in order to demonstrate the efficacy of rehabilitation intervention even in clinical pictures in which a hearing deficit is associated with performance retardation, a not uncommon condition. Each child underwent a brief period of training with the different materials so that the instructions of the various tests would be clear; each child was then evaluated by means of the two batteries, with a week elapsing between one evaluation and the other. A programme of auditory perception rehabilitation was carried out for a period of six months, with two speech/language therapy sessions weekly and consolidation work at home with the participation of the patient's parents. At the end of this period, each child underwent re-evaluation by means of the two batteries, once again a week apart. To ensure maximum homogeneity in the results, all tests in these children were administered by the same person.

Materials

The tests employed were those of EARS and the battery constituting the Evaluation of Speech Perception in the Deaf Child. The latter comprises the ESP, GASP, NU-CHIPS, and WIPI tests. The ESP test includes three subtests: the first evaluates the identification of syllabic patterns, while the other two evaluate the identification of bisyllables and quadrisyllables. The GASP test is divided into three parts: one regarding phoneme detection, one word identification, and one question comprehension. NU-CHIPS and WIPI test the identification of bisyllables that differ in a single phoneme.

Table I. Results, in percentages, on first and second administration of EARS battery subtests.

Child	LiP		BTP		BLC		TH		RB		GASP		RF	
1	100	100	100	100	100	100	92.8	93	90	90	90	100	90	90
2	100	100	95.8	100	87.5	100	13.1	33.3	40	40	90	100	0	30
3	100	100	100	100	100	100	26.4	33.6	20	60	Ns	100	Ns	20
4	90	100	62.5	83.3	70.8	100	4.6	11.5	Ns	10	Ns	Ns	Ns	0
5	90.5	100	41.7	75	58.3	50	7.4	10.3	Ns	20	Ns	Ns	Ns	30
6	61.9	83.3	Ns	58.3	Ns	75	Ns	0	Ns	10	Ns	Ns	Ns	0
7	54.8	88.1	Ns	41.7	Ns	0	Ns	0	Ns	0	Ns	Ns	Ns	0
8	4.8	57.4	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
9	42.9	59.5	Ns	75	Ns	100	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
10	Ns	88.1	Ns	4.8	Ns	37.5	Ns	0	Ns	0	Ns	Ns	Ns	0
Wilcoxon test	W=–28.0		W=–10.0		W=–19.0		W=–15.0		W=–10.0		W=–6.0		W=–6.0	
	p<0.016		cdr		p=0.062		p=0.062		cdr		cdr		cdr	

Ns indicates that test could not be administered, and was calculated as 0 in statistical analysis; cdr indicates that size of sample is too limited to be able to administer Wilcoxon test.

The EARS test is made up of several subtests. LiP (Listening Profile) is a test of detection, discrimination and identification of environmental sounds, instrument sounds and phonemic phons. BTP (Bisyllables, Trisyllables, Polysyllables) tests the identification of syllabic patterns and is, therefore, similar to the ESP subtest. BLC (Bisyllables in a Closed List) tests the identification of bisyllables and is, therefore, similar to the ESP subtest. Tyler-Holstad (TH) tests the identification of connected speech. Lastly, there are three tests in open sets: one regarding the repetition of bisyllables (RB), one on the repetition of phrases (RF) and one on interrogative sentences (identical to GASP). This last subtest, since it is identical in the two test batteries under examination, enables us to evaluate intrasubjective variability.

The results of each subtest were recorded as percentages of correct answers; comparisons may, therefore, be made between different subtests and different batteries. In those cases in which the test could not be administered, a score of 0 was attributed during statistical analysis; inability to administer the test is, in fact, to be considered as a primitive stage in the development of hearing perception, preceding that evaluable by the test. Passing from a condition of non-administrability to one with a 10% average may be considered at least equal to advancing from 0% to 10%.

The data regarding the first and second test administrations were compared using the Wilcoxon test; the p value was read on the basis of the critical values of the W test in Mosteller and Rourke's classification [7]. Similar subtests in the two test batteries were analysed with the Spearman range correlation coefficient.

Results

Data related to the first and second administrations of the Arslan et al. and EARS batteries are shown in Tables I and II. The first fact that emerges is the increase in the children's compliance to the administration of the test. It can, in fact, be observed that the number of tests that could not be administered due to poor collaboration or because the task required was too difficult for the children's skills passed from 38/70 to 15/70 for the EARS test and from 51/80 to 13/80 for the Evaluation of Speech Perception in the Deaf Child test. Likewise, it was possible to record, for almost every child, the progress observed during the speech therapy sessions. Worthy of note is the fact that even in those children whose general performance development was inadequate for their age, the rehabilitation therapy gave tangible results. Equally interesting is the improvement seen in the open-set tests within the six months and the evident correlation with the results achieved in the closed-set tests. With the instrument elaborated by Arslan et al., moreover, a tangible improvement could be observed in every child, including also those with performance retardation. The only exception being child 8. A statistically significant difference was observed in the LiP tests and in the first ESP subtest. The limited number of open-set tests performed made evaluation unfeasible, and therefore no statistical analysis can

Table II. Results in percentages on first and second administration of test battery of Evaluation of Speech Perception in the Deaf Child.

Child	ESP a		ESP b		ESP c		GASP a		GASP b		GASP c		NU-CHI.		WIPI	
1	100	100	100	100	87.5	100	84.6	100	100	100	80	100	86	96	76	92
2	87.5	100	79.2	100	91.7	100	100	100	79.2	100	80	100	66	86	68	72
3	100	100	83.3	100	100	100	100	100	83.3	100	Ns	90	Ns	76	Ns	56
4	66.7	100	45.8	79.2	Ns	91.7	Ns	100	Ns	95.8	Ns	0	Ns	76	Ns	40
5	79.2	70.4	12.5	12.5	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0
6	4.2	62.5	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0
7	12.5	33.3	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0
8	0	0	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
9	Ns	79.2	Ns	78	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
10	Ns	28.2	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0	Ns	0
Wilcoxon test	W=–26.0 p<0.046		W=–10.0 cdr		W=–6.0 cdr		W=–3.0 cdr		W=–6.0 cdr		W=–6.0 cdr		W=–10.0 cdr		W=–10.0 cdr	

Letters a, b, and c next to test acronyms indicate the three parts in which each test is subdivided. Ns indicates that test could not be administered, and was calculated as 0 in statistical analysis. Cdr indicates that size of sample is too limited to be able to administer Wilcoxon test.

be made. Examination of the test data reveals, however, that, in most cases, no variations occurred during the second evaluation. This finding is hardly surprising, since these tests are much more difficult.

A comparison of the subtests with similar characteristics, belonging to the two different batteries is shown in Table III, where it can be seen that, in most of the tests, the majority of the children scored similarly, on similar tests. If the results of the first and second administrations of the GASP question test are compared, a certain variability between one subject and another is found. This is not to be attributed to different degrees of development attained in the perception skills nor to differences in the way these skills are detected by the two subtests, but to other factors, such as the degree of attention paid by the child being examined or his/her motivation in that particular moment. The Spearman range correlation coefficient has revealed how similar subtests effectively detect similar skills. In fact, re-

Table III. Comparison between results in percentages on first and second administration of first two parts of ESP test and results of corresponding BTP and BLC tests.

Child	BTP I	ESPa I	BTP II	ESPa II	BLC I	ESPb I	BLC II	ESPb II
1	100	100	100	100	100	100	100	100
2	95.8	87.5	100	100	87.5	79.2	100	100
3	100	100	100	100	100	83.3	100	100
4	62.5	66.7	83.3	100	70.8	45.8	100	79.2
5	41.7	79.2	75	70.4	58.3	12.5	50	12.5
6	Ns	4.2	58.3	62.5	Ns	Ns	75	0
7	Ns	12.5	41.7	33.3	Ns	Ns	0	0
8	Ns	0	Ns	0	Ns	Ns	Ns	Ns
9	Ns	Ns	75	79.2	Ns	Ns	100	78
10	Ns	Ns	4.8	28.2	Ns	Ns	37.5	0
Spearman corr. coefficient	R sub S=0.939 p<0.0001		R sub S=0.979 p<0.0001		R sub S=0.997 p<0.0001		R sub S=0.894 p<0.002	

Ns indicates that test could not be administered, and was calculated as 0 in statistical analysis. Comparison of GASP test in the two batteries yielded a Spearman r sub coefficient S=0.991 with p<0.0001 on both first and second administration.

sults between 0.894 and 0.997 is obtained; it should be noted that the same test, administered by the same examiner, a week later, showed a Spearman coefficient of 0.991.

Discussion

During the study, the major differences between the two test batteries emerged. The EARS battery enables a wide spectrum of auditory perception to be evaluated. In fact, the presence of the LiP subtest, which may be administered from 18 months of age, makes it possible to record the evolution of very early stages of perception [2]. This aspect was, in fact, very important in several children e.g., 8, 9 and 10, and decisive for one of them. At the same time, the TH test allows the evolution of connected speech perception abilities to be assessed. This often-neglected aspect is, instead, of considerable importance in that it enables the evolution from single word perception to phrase perception to be evaluated.
In the Evaluation of Speech Perception in the Deaf Child battery, tests such as WIPI and NU-CHIPS are extremely valid in clinical practice, as they evaluate the perception of minimum pairs and, therefore, allow the rehabilitation process to be targeted, especially as regards the spectrum and duration of the phoneme and, furthermore, it is possible to highlight residual difficulties, which other tests are unable to pick up. An analysis of the results shows a series of five points worthy of our attention: 1) auditory perception training improves the compliance of the child in the formal evaluation of this ability; 2) the existence of two different instruments using the Italian language for the quantitative evaluation of auditory perception of children affected by severe and profoundly severe prelingual deafness; 3) the possibility of detecting a marked improvement in perception skills, even over a limited period of time (six months); 4) the possibility of ascertaining improvement in auditory perception even in subjects in whom mental retardation is associated with deafness; 5) minimum variability in similar subtests on different tests.
A much-neglected issue is that of children presenting mental retardation associated with severe or profoundly severe sensori-neural deafness. While clearly these cases require a more detailed diagnosis and their abilitation process should be prevalently targeted along the educational lines proposed for the mentally retarded, the findings emerging from our study, though based on a limited number of patients, confirm that these patients benefit from auditory perception rehabilitation programmes. Despite the limited number of cases examined, the present observations suggest that an improvement in auditory perception has a positive effect on the development of other abilities, especially of a cognitive order. It is hardly surprising that improving the perceptive abilities related to one sensory canal also affects the perception skills of the other canals as well as the central processing of stimuli in general.

References

[1] Schindler O, Vernero I, Utari C, Schindler A. *Stato dell'arte della riabilitazione logopedica del bambino sordo*. Riabilitazione Oggi 1998;7:13-5.

[2] Schindler O, Schindler A, Utari C, Vernero I. *I quanta acustici nell'informazione e nella comunicazione* I Care 2000;1:12-6.

[3] Schindler O, Vernero I, Schindler A. *L'elaborazione centrale del messaggio acustico.* L'educazione dei sordi 1998;3:167-82.

[4] Masterton RB. *Role of the central auditory system in hearing: the new direction*. Trends in Neuroscience 1992;15:280-5.

[5] Schindler O. *La perception auditive: parametrisation en 9 categories*. Folia Phoniatr Logop 1986;5-6:350.

[6] Schindler O, Schindler A. *Indicazioni a confronto: protesi acustica o impianto cocleare?* Acta Phoniatrica Latina 1999;1-2:83-7.

[7] Mosteller F, Rourke R. *Study statistics, nonparametrics and order statistics.* Reading, MA: Addison-Wesley; 1973.

[8] Erber NP. *Auditory training.* Washington DC: Alexander Graham Bell Association for the Deaf; 1982.

[9] Schindler O, Vernero I. *Comunicazione e linguaggio del bambino ipoacusico*. Orl Ped 1992;3:291-317.

[10] Kirk IL, Diefendorf AO, Pisoni DB, Robbins AM. *Assessing speech perception in children.* In: Mendel LL, Danhauer JL, editors *Audiological evaluation and management and speech perception assessment.* San Diego, CA: Singular Publishing Group; 1997.

[11] Arslan E, Genovese E, Orzan E, Turrini M. *Valutazione della percezione verbale nel bambino ipoacusico.* Bari: Ecumenica Editrice srl; 1996.

[12] Allum D. *EARS (Evaluation of auditory responses to speech).* Innsbruck: Med-El; 1998 (Italian version, Milan: Mercury).

[13] Schindler A, Gilardone M, Guglielmino P, Manassero A, Ottaviani F. *Alcune riflessioni sulla percezione uditiva*. Abilitazione e Riabilitazione 2000;1:38-47.

[14] Archbold S. *Monitoring progress in children at the pre-verbal stage.* In: McCormick B, Archbold S, Sheppard S, editors. *Cochlear implants for young children.* London: Whurr Publishers Ltd; 1994.

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