

Treating Auditory Comprehension Deficits With a
Tactile Aid: a Preliminary Report

Robert T. Wertz, Pierre L. Divenyi, Gretchen Skalbeck,
Cindi Dwyer, Jane Baxter, Frank A. Saunders

Veterans Administration Medical Center, Martinez, California

Treatment methods for severe auditory comprehension deficits in aphasic patients are few. What does exist is not very effective. Recent advances in the development of sensory substitution aids, specifically those that provide transmission of information through tactile sensation, provide potential treatment.

Spens (1980) has compared a variety of speech-conveying tactile systems. These are shown in Figure 1. They vary in their placement on the body--finger (Spens, 1976); palm (Traunmyller, 1977; Schulte, 1972); wrist (Schulte, 1972); torso (Sparks, 1978); abdomen (Saunders, 1973; Scott *et al.*, 1977); and thigh (Englemann and Rosov, 1975), and they vary in the number of vibrators employed--one, by Traunmyller (1977) and Schulte (1972), to an eight by 32 matrix by Sparks (1978). All are designed to convert acoustic information to tactile pulses that are displayed on the skin. Spens (1980) concludes that the best area to stimulate is the fingers, that stimuli with large spectral changes are easier to learn than those with small spectral changes, and that aids should be portable to permit training over a long period of time.

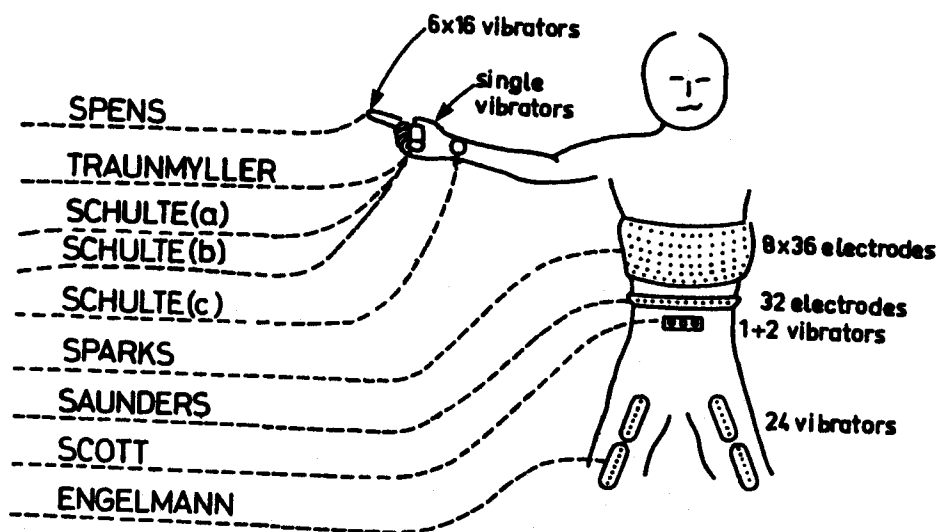


Figure 1. Speech-conveying tactile systems. (After Spens, 1980).

While tactile sensory substitution of auditory information has been reserved for deaf and severely hard of hearing patients (Saunders, 1973) the method may be appropriate for aphasic patients who suffer severe auditory comprehension deficits. Some aphasic patients have improved their oral expressive use of language through intersystemic reorganization

Treatment follows a stimulus-response paradigm utilizing principles of programmed instruction, specifically, paired associate and forced-choice response. Tasks are arranged in a hierarchy of ascending difficulty beginning where the patient demonstrates auditory comprehension problems. During the treatment periods when the patient wears the belt, the auditory signal is transduced by the belt to electro-tactile stimulus patterns on the abdomen that are not unlike the acoustic patterns found in the inner ear. A siren, for example, will produce a sensation moving right, to left, to right on the abdomen. Similarly, each speech sound will generate its own characteristic pattern.

RESULTS

Two patients have completed the treatment trial. The first (L.D.) met selection criteria but was later discovered to have suffered a previous right hemisphere CVA in addition to a left hemisphere CVA. He was 14 months postonset when we began. He displayed significant improvement on the treatment tasks. However, criterion measures showed no improvement during the treatment trial. PICA Overall performance at intake, shown in Figure 3, was at the 55th percentile, and after eight and 16 weeks of treatment, it remained at the 55th percentile. Similarly, his CADL (Holland, 1980) total score was unchanged, 91 at intake and 91 at the end of the trial. The Token Test (Spreeen and Benton, 1969) total score deteriorated, 139 at intake and 126 at the end of the trial. L.D. was randomized to the treatment trial that presented the first eight weeks of treatment without the belt. Figure 4 shows performance on a two-step auditory comprehension task -- pointing to two pictorially represented nouns in a matrix of ten that differed acoustically and semantically. It is representative of his performance on all treatment tasks. During the first eight weeks, treatment without the belt, performance increased from 78% correct in baseline to 92% correct at eight weeks. During the second eight weeks, treatment with the belt, performance increased to 100% correct.

The second patient (W.M.) was three years postonset from a left hemisphere CVA at entry. He met all selection criteria. W.M. made significant gains on the treatment tasks when he wore the belt. Similar gains were not seen during treatment without the belt. Criterion measures improved during the trial. PICA Overall performance, shown in Figure 5, was at the 17th percentile at intake, at the 27th percentile after eight weeks of treatment with the belt, and at the 31st percentile after eight weeks of treatment without the belt. Performance on the CADL was a total score of 55 at intake, 64 after eight weeks of treatment with the belt, and 49 after eight weeks without it. His Token Test total score was 17 at intake, 27 after eight weeks of treatment with the belt, and 31 after eight weeks without it. W.M. was randomized to the treatment trial that presented the first eight weeks of treatment with the belt and the second eight weeks of treatment without the belt. Figure 6 shows performance on a one-step auditory comprehension task -- pointing to a pictorially represented noun in a matrix of ten nouns that differed acoustically but were related semantically. It is representative of his performance on all treatment tasks. During the first eight weeks, treatment with the belt, performance increased from 30% correct in baseline to 58% correct at eight weeks. During the second eight weeks, treatment without the belt, performance decreased to 56% correct.

Porch Index of Communicative Ability

MODALITY RESPONSE SUMMARY

Name L.D. Case No. _____
 Age 62 Birthdate 1/5/19 Sex M Race _____ Handedness R - R Used
 Diagnosis Bilateral CVA Onset 1/1/80
 Date 3/31/81 Overall 9.24 Gestural 13.53 Verbal 4.48 Graphic 6.70
 Date 6/25/81 Overall 9.50 Gestural 13.52 Verbal 4.30 Graphic 7.60
 Date 9/1/81 Overall 9.60 Gestural 13.78 Verbal 4.25 Graphic 7.58

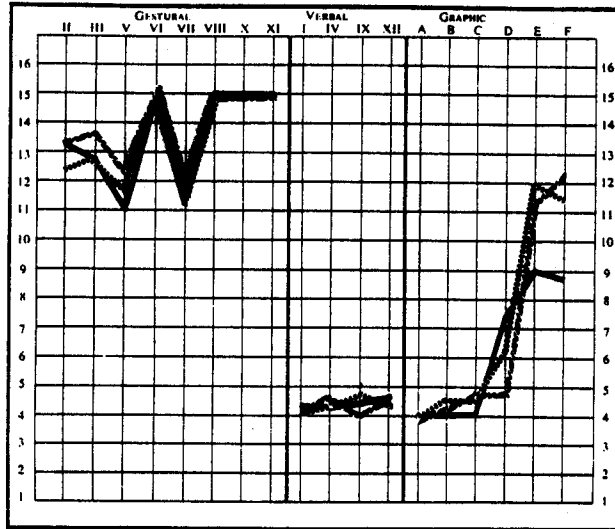


Figure 3. PICA Modality Response Summary for L.D. showing performance at intake, after eight weeks of treatment without the belt, and eight weeks of treatment with the belt.

Published by
CONSULTING PSYCHOLOGISTS PRESS
 577 College Avenue
 Palo Alto, California

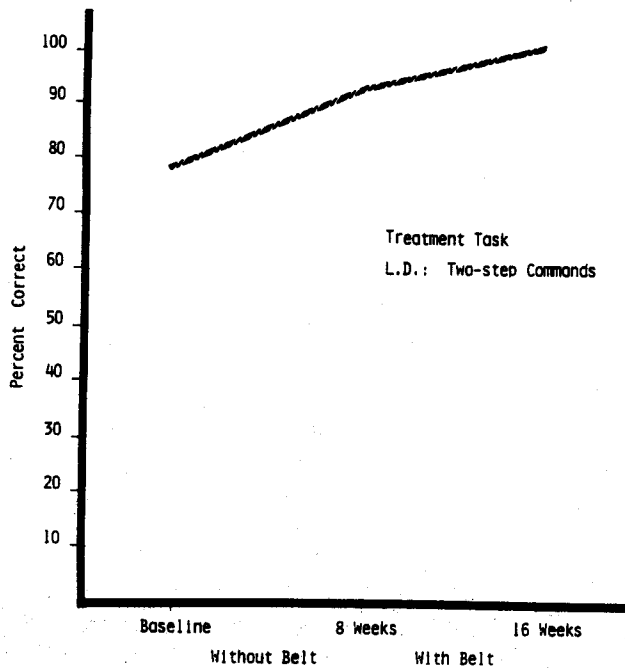


Figure 4. L.D.'s response to a two-step auditory command treatment task.

Porch Index of Communicative Ability

MODALITY RESPONSE SUMMARY

Name W.M. Case No. _____
 Age 65 Birthdate 4/4/16 Sex M Race _____ Handedness R - L Used
 Diagnosis Left Hemisphere CVA Onset 3/17/78
 Date 5/5/81 Overall 6.85 Gestural 7.51 Verbal 8.30 Graphic 5.00
 Date 7/22/81 Overall 8.08 Gestural 9.51 Verbal 7.55 Graphic 6.55
 Date 10/6/81 Overall 8.46 Gestural 10.34 Verbal 8.10 Graphic 6.18

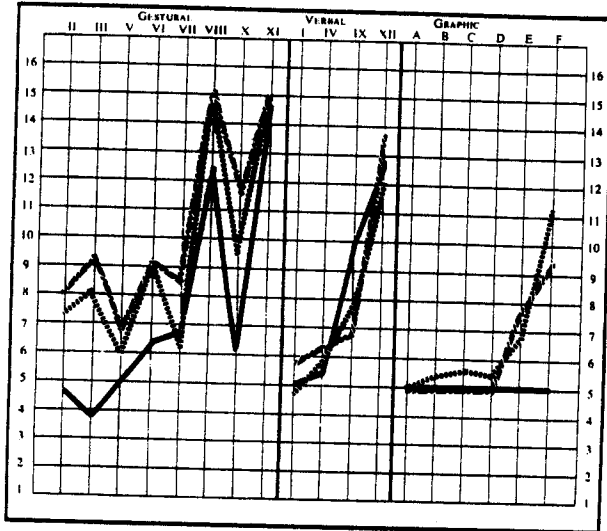


Figure 5. PICA Modality Response Summary for W.M. showing performance at intake, after eight weeks of treatment with the belt, and eight weeks of treatment without the belt.

Published by
CONSULTING PSYCHOLOGISTS PRESS
 877 College Avenue
 Palo Alto, California

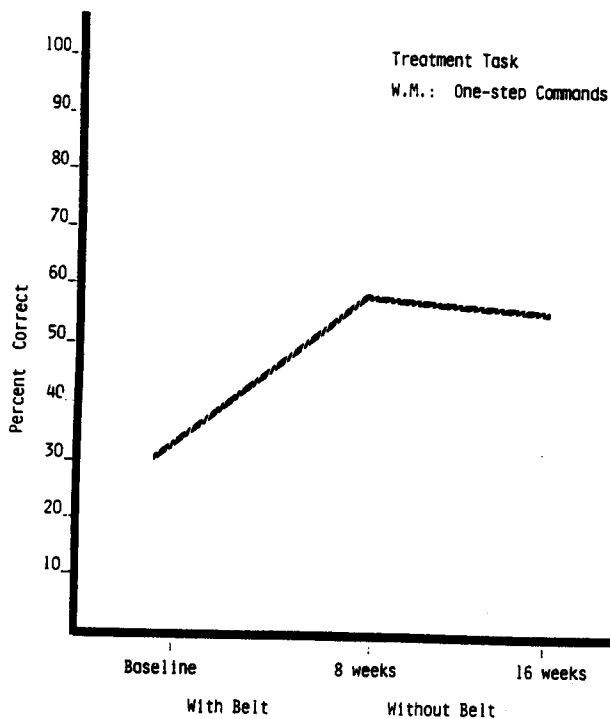


Figure 6. W.M.'s response to a one-step command treatment task.

DISCUSSION

Few conclusions can be drawn from the performance of two patients. The patient who did not improve on criterion measures during the treatment trial was discovered to have bilateral lesions. Further, his auditory comprehension met selection criteria, but it was not severely depressed (72nd percentile on the Token Test at intake). And his treatment trial was randomized into eight weeks without the belt followed by eight weeks with the belt. The patient who improved on criterion measures met all selection criteria, demonstrated more severe auditory comprehension deficits (6th percentile performance on the Token Test at intake), and received eight weeks of treatment with the belt followed by eight weeks of treatment without the belt. Therefore, it may be inappropriate to compare performance between these patients who differ in the cortical localization of their lesions, severity of auditory comprehension deficits, and the sequence of tactile belt treatment during the trial.

Both patients improved on treatment tasks during the first eight weeks of the trial. That improvement may be a response to treatment and have little to do with the presence or absence of the tactile belt. Some chronic aphasic patients improve when they are treated (Smith, 1972; Broida, 1977) regardless of what the treatment is. Our design -- eight weeks with the belt and eight weeks without it -- may be confounded by time.

We have modified our design and the method for presenting stimuli and recording responses. Presently, we are using a 20-session, random assignment of treatment design in which subjects receive criterion measures at intake, baseline testing on a single auditory comprehension task, 20 randomized treatment sessions -- ten with the belt and ten without -- and post-treatment evaluation with criterion measures. We evaluate at baseline, after each treatment session, and post-treatment in three conditions: auditory only, tactile only, and auditory-tactile combined. Comparison of performance following treatment sessions with and without the belt and comparison of performance among conditions -- auditory, tactile, and auditory-tactile combined -- should permit us to test the efficacy of tactile sensory substitution as a treatment for severe auditory comprehension deficits in aphasic patients.

Further, we have developed a computer system to generate and present the auditory and tactile stimuli and record each subjects' responses. This avoids the lack of control and differences inherent in presenting auditory and tactile stimuli via live voice.

It is necessary to collect more data on more patients to test the efficacy of treating auditory comprehension deficits in aphasia with a tactile aid. We are doing that. Certainly a rationale can be laid for this effort. We are dealing with a group of patients suffering deficits that do not have a viable treatment. The use of sensory substitution as a mode of treatment for a variety of disorders is being hawked as effective by a number of rehabilitation disciplines. Unfortunately, empirical evidence is lacking to support these claims. We cannot advocate putting a tactile belt on all aphasic patients, nor do our results qualify us for a no belt prize. A test of the efficacy of the TELEACTOR for assisting aphasic patients appears to be both timely and essential.

ACKNOWLEDGMENT

This research is being supported by a grant from the Veterans Administration Rehabilitation Engineering Research and Development.

REFERENCES

- Broida, H. Language therapy effects in long term aphasia. Archives of Physical Medicine and Rehabilitation, 58, 248-253, 1977.
- Englemann, S. and Rosov, R. Tactual hearing experiment with deaf and hearing subjects. Exceptional Children, 41, 243-253, 1975.
- Holland, A.L. Communicative Abilities in Daily Living. Baltimore: University Park Press, 1980.
- Porch, B.E. Porch Index of Communicative Ability. Palo Alto, California: Consulting Psychologists Press, 1973.
- Rosenbek, J.C., Collins, M.J. and Wertz, R.T. Intersystemic reorganization for apraxia of speech. In Brookshire, R.H. (Ed.), Clinical Aphasiology Conference Proceedings. Minneapolis, MN: BRK Publishers, 1976.
- Saunders, F.A. An electrotactile sound detector for the deaf. IEEE Trans. Audio and Electroacoust., AU-21, 285-287, 1973.
- Schulte, K. Fonator system: Speech stimulation and speech feed-back by technically amplified one-channel vibrations. In Fant, G. (Ed.), International Symposium on Speech Communication Ability and Profound Deafness. Washington, D.C.: A.G. Bell Association for the Deaf, Paper 36, 1972.
- Scott, B.L., de Filippo, C.L., Sachs, R.M. and Miller, J.M. Evaluating with spoken text a hybrid vibrotactile electrotactile aid to lip-reading. Paper presented to the Research Conference on Speech-Processing Aids for the Deaf, Gallaudet College, May 1977.
- Smith, A. Diagnosis, Intelligence, and Rehabilitation of Chronic Aphasics: Final Report. Ann Arbor: Department of Physical Medicine and Rehabilitation, University of Michigan, 1972.
- Sparks, D.W. Investigating the MESA (Multipoint Electrotactile Speech Aid): The transmission of segmental features of speech. Journal of the Acoustical Society of America, 63, 246-257, 1978.
- Spens, K.E. Speech defects and aids: Tactile speech communication aids for the deaf, a comparison. Paper presented to the International Congress on Education of the Deaf, Hamburg, August 1980.
- Spens, K.E. Preliminary results from experiments on recognition of spectral patterns on a vibrator matrix with different time windows. Quarterly Progress and Status Report, Speech Transmission Laboratory, Stockholm, 2-3, 1976.
- Spreen, O. and Benton, A.L. Neurosensory Center Comprehensive Examination for Aphasia (Edition A). Victoria: Neuropsychology Laboratory, University of Victoria, 1969.
- Traunmyller, H. The Sentiphone. Paper presented to the Research Conference on Speech-Processing Aids for the Deaf, Gallaudet College, May 1977.

DISCUSSION

- Q: I wonder why you did not add an additional condition, one where the patient hears the auditory stimuli but receives tactile vibrations that do not represent the auditory stimuli. This would serve as a control to insure that the correct tactile stimuli really do assist in auditory comprehension. Without this condition, any improvement you might see could result from just wearing the belt and receiving vibrations and have nothing to do with whether the tactile stimulus represented the auditory stimulus.
- A: That is a good point. We do have a check on your concern. There is a condition where we look at what the patient does with only the tactile representation of the auditory stimulus without hearing the auditory stimulus. The data to date indicate some improvement in this condition, for example from 10 percent correct in baseline to 17 percent correct after treatment. Using a matrix of ten stimuli, this improvement is close to chance. We could add the condition you suggest in our daily criterion runs, but I worry about confusing the patient by giving him tactile misinformation.
- Q: What do you tell the patients when you put the belt on them?
- A: We have a standard set of instructions that indicate they will feel vibrations on the belly in certain conditions, that they should pay attention to these, and that the vibrations may help them understand what they hear.
- Q: Why did you pick the abdomen to stimulate? I don't think it is the best place to present a tactile stimuli.
- A: You are probably correct. Spens says the finger is superior to other areas of the body. Of course, it was Spens who developed the finger vibro-tactile stimulator. We selected the abdomen because the device available to us was Saunders' TELEACTOR belt. His research with deaf children implied it may be useful as a sensory substitution device.
- Q: Have you thought about using a multiple baseline design?
- A: Yes. We found our first design--16 weeks (eight weeks wearing the belt and eight weeks not wearing the belt) was too long, and it was confounded, probably, by time. We have switched to a 20-session, random assignment of treatments design, ten wearing the belt and ten not wearing the belt. We may consider a multiple baseline design in the future.
- Q: How many baselines do you run? Are they stable? How many trials?
- A: We run three baselines in each condition on three separate days. Each baseline in each condition consists of ten trials. Baselines, so far, are stable, within plus or minus ten percent. We run 50 trials during each treatment session, followed by daily criterion measures, ten trials each in three conditions.
- Q: Is the instrument FDA approved? I worry about safety.
- A: The belt is FBA approved, Food and Belly. It meets all safety requirements for electrical hazards. It has passed several Human Studies Committees' review both in our study and previous studies by Saunders.

We have exclusion criteria--for example, no patient who wears a pacemaker participates.

Q: Because the belt helped deaf children develop a vocabulary does not mean it will help an aphasic patient's auditory comprehension. The deaf child has no auditory signal coming in. The aphasic patient does. I suspect the inefficiency of auditory to tactile conversion and several other problems will not make the belt very useful. The aphasic patient will not depend on it.

A: You could be correct. We are doing the study to find out.

Q: Just one more comment. There is a literature that says speech is so special, there is no way to substitute for hearing it. Many have given up trying, because no other system can handle the amount of information conveyed by auditory stimuli.

A: We are familiar with that literature. It may be correct. We are also familiar with the literature that implies that sensory substitution is a panacea for a variety of ills. Unfortunately, there are few data to support the efficacy of sensory substitution. We are conducting the treatment trial to collect some empirical evidence. The time to test a potential treatment is before it becomes an accepted treatment without empirical support. That happened to us in aphasia. I would not like to see that situation duplicated in the use of sensory substitution.