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TACTILING: A USABLE SUPPORT SYSTEM FOR SPEECHREADING?*

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Abstract
The purpose of this study was to find out whether a deafened adult can take advantage of the added information given by the vibrational and motional patterns he/she picks up by placing his/her hand on a speaker's throat and shoulder, and how valuable that is as a support system for speechreading. We have named this method Tactiling. Eight deafened adults participated in the study, which was conducted as a pretest-posttest control group design. The experimental and the control groups took speechreading classes together. The experimental group received additional individual training in Tactiling during six lessons. Both the experimental and the control groups were tested, before and after training, first by a familiar person and after a fortnight by an unfamiliar person. A three-way ANOVA demonstrated two significant main effects. Tactiling is generally better than speechreading, and the results from the test given by the familiar speaker are better than with the unfamiliar speaker. No additional main or interaction effects of training were obtained. The main effect of Tactiling over speechreading suggests that the method is worth pursuing as a support system for speechreading. Possible reasons for the direct effect of Tactiling and lack of main effect of training are discussed, as well as modifications of this "natural" device.

INTRODUCTION
For the severely hearing-impaired and the deafened adult, communication through the auditory channel is at best very difficult and often impossible. As the auditory channel is more or less deficient, the hearing-impaired individual has to use to a large extent the visual channel for the input of speech information. Consequently, speechreading becomes more important for their communication. However, speechreading is a difficult task since most of the speech sounds are not possible to identify visually. Common estimates give approximately 10-25% of speech sounds as visible (Dodd, 1977; Jeffers & Barley, 1977, for a review; Woodward & Barber, 1960; Amcoff, 1970, for Swedish stimuli). The task can be made easier for the hearing impaired when he combines the visual information with the auditory information given by the residual hearing and a hearing aid. The available alternatives for the profoundly deafened adult are vibrotactile aids or cochlear implants.

Research on and development of vibrotactile aids have a long history (Reed, Durlach, & Braida, 1982; Spens 1984). Several tactile aids, both single and multi-channel, are commercially available (Franklin, 1988). Evaluative studies have been made with some of these aids (Cholewiak & Sherrick, 1986; Lynch, Eilers, Oller, Urbano, & Pero, 1989; Plant, 1989; Weisenberger & Russell, 1989) as well as others still at the laboratory stage (Boothroyd & Hnath-Chisholm, 1988; Plant, Macae, & Dillon, 1984;
Weisenberger & Miller, 1987). These studies show that a single-channel or a twin-channel tactile aid offer some ability to identify environmental sounds and some support during speechreading. Better results are usually obtained with the multi-channel aids (Weisenberger, Broadstone, & Sounders, 1989).

During the last years, direct stimulation of the cochlea with a cochlear implant has become a viable alternative for those with a total hearing loss (Ganz et al., 1988). In some of the patients, fitted with a cochlear implant, speech understanding is possible even without simultaneous use of speechreading (Dowell, Mecklenburg, & Clark, 1986). However, due to the difficulty these devices have in distinguishing between speech sounds and environmental noise, the hard of hearing person will experience difficulties when these aids are used in many everyday situations.

We are personally acquainted with a man (GS), who uses an almost unknown tactile aid to speechreading, here called Tactiling. During Tactiling he holds his hand on the shoulder and throat of the speaker. He receives tactile information from the vibrations of the larynx as well as visual information from the lip movements. Compared to other methods, Tactiling is only sensitive to the speech signal with no interference from environmental noise. Thus, the purpose of the present paper was to investigate the potential merits of the method used by GS.

**Description of GS**

GS is a 52 years old male swede. Measured with pure tone audiogram, he has no hearing. He became deaf at the age of eight as the result of meningitis. His parents were then taught — according to current wisdom and educational programs in Sweden — to speak slowly in his ear (Wedenberg, 1953). He sat in his mother's or father's lap while he or she read a story in a loud voice into his ear. He was supposed to follow the story in the book. As he could not benefit from any auditory information, he detected the rhythmic vibratory pattern in the parents' throat region. When he held his hand on the parents' throat and at the same time looked at their faces, he noticed that it was easier to follow and understand their speech. Thus, he spontaneously combined the visual information with the Tactiling information provided by the vibrations he felt in his hand.

Although he found it more effective to hold the hand directly on the speaker's throat, with the palm over the larynx and the fingers spread around the neck, this method was not socially acceptable. After about a month he changed it to a more acceptable form of Tactiling. This was accomplished by changing the position of the hand such that the fingers were placed lightly on the speaker's shoulder with the thumb resting against the speaker's neck. By using this method, GS was able to attend his former school among hearing classmates. He became deaf in June and was back in school in September, the same year. He managed a normal education up to university level (Söderlund, 1984).

The performance of GS has been studied by Plant & Spens (1986) using a number of different speech tests. He is a skilled speechreader with a performance of around 40 words per minute when measured with speech tracking. Speech tracking is a method where the subject has to repeat a text, word by word. The dependent variable is the number of words perceived per minute (wpm, DeFilippo & Scott, 1978). When Tactiling, his score is higher than 60 words per minute. This should be compared to the average 83 wpm for normal hearing Swedes (Ohngren & Cook, 1990), thus indicating that he was able to communicate with people without greater difficulties.

A similar method is used by the deaf-blind: the Tadoma method (Read & al., 1985). With this method, speech is received by placing the hand on the talker's face, thus monitoring facial activities associated with speech production. Here, performance is roughly equivalent to that of normal-hearing people listening in noise or babble with a signal-to-
noise ratio in the range of 0-6 dB (Read & al., 1985). The typical placement of the hand of a Tadoma user is that the thumb rests lightly on the talker’s lips while the fingers fan out over the face and neck. The deaf-blind individual is then able to use the information from lip movements, jaw movements, oral/nasal airflow, and laryngeal vibration. For the hard of hearing, speechreading is essential, so having his fingers fan out over the speaker’s face will obviously interfere with his ability to speechread.

As speech understanding for the Tadoma users is good, and due to the fact that there is an interesting similarity between Tactiling and the Tadoma method – that is, the use of the hand to understand speech – two questions will be investigated in this study. First, when Tactiling, can the profoundly hard of hearing individuals combine the information from the vibrations in the hand with the visual information of the talker’s lip movements and face, such that speechreading is improved, or is this method unique to GS? Second, is this an ability that could be used immediately, or is training needed?

METHOD

Subjects
The subjects were eight deafened adults, six men and two women, aged 28–53 years (mean age 39.7 years, SD=9.1). The mean duration of the hearing loss was 23 years, ranging from 5–41 years. The mean average hearing threshold (500, 1 000, and 2 000 Hz) for three of the subjects was 95 dB (HL), the other five had no measurable residual hearing. Two of the three subjects with measurable hearing used a hearing aid, as they could make use of some prosodic information. The third subject did not benefit from having a hearing aid. All subjects participated in a speechreading course at the Rehabilitation Centre for the Hard of Hearing in Uppsala, Sweden, and were enrolled from the local association for the hard of hearing. They varied from skilled to less skilled speechreaders and were engaged in the speechreading course to maintain or to improve their speechreading abilities. Four of the subjects had previous experience with the Minivibrator (Special Instruments, Stockholm) but they had chosen not to use this aid, as it did not give them enough additional support to speechreading.

The speechreading class was held eight times – once a week during two and a half hours. The subjects were informed about the Tactiling method during the first meeting and were asked whether they were interested in participating in a training experiment with Tactiling. All subjects agreed to the proposal. The subjects were informed about how GS uses Tactiling and were then instructed to try to find the place on the speaker’s throat where the vibrational and motional patterns were felt best. Since all subjects were familiar with the person (GO), whom they were supposed to try Tactiling on, no social problems were expected to interfere with their performance. None of the subjects chose to hold the hand, as GS does now, instead they all placed the hand as GS did in the beginning; that is, with the palm over the larynx, the thumb on one side of the neck, and the other fingers on the other side of the neck.

Materials
Speechreading: training materials. The training materials used in the speechreading training sessions, by all subjects, had both a synthetic and an analytic structure (Jeffers & Barley, 1977). Both the experimental and the control groups were trained at the same time, the same material (Lundmark, 1981), and the same teacher. Three teachers were involved in the training changing from session to session.

Tactiling: training materials. The training material for the group receiving Tactiling training was a textbook in the Mouth-Hand-System [MHS] (Ekström, Miller, & Öhn-
MHS, which is similar to cued speech (Cornett, 1972), was constructed by Forchhammer (Børild, 1972), who suggested that through a demonstration of the positions of the invisible speech organs, it was possible to make speech just as perceptible by the eye as it is by the ear. The sounds that – when articulated by the speaker – cannot be seen on the speaker's face are thus marked with special hand and finger patterns. The hard of hearing then combines the speaker's lip movements with the hand and the finger movements. As the purpose of this study was to investigate a support system for speechreading, and as there is no training material available for Tactiling, the MHS training material was considered appropriate. Specifically, the MHS materials were chosen because of its systematic strategy of improving the ability to combine speechreading information with supporting information.

**Procedure**

The experimental and the control groups took their eight speechreading lessons together. Since it was expected to be too tiring for the experimental group to participate in Tactiling training after or before the speechreading training lessons, the subjects in the experimental group received their training individually at separate occasions. Before the training started, all subjects were given a live speechreading test (prespeech A/GO/) and a live Tactiling test (pretact A/GO/). The test material was developed by Lyxell & Rönning (1989) and has been reported in the literature (Lyxell, 1989; Rönning, 1990; Rönning, Arlinger, Lyxell, & Kinnefors, 1989). The test consists of 24 simple, declarative Swedish sentences. The sentences are subdivided into three blocks. Each block of eight sentences refers to one contextual scenario. Each scenario – a restaurant scenario, a travelling by train scenario, and a clothing shop scenario – informs the subjects about the global topic. The description of the scenario was provided in print. The Tactiling test was constructed according to the same principles as the speechreading test.

**Tactiling training session.** In the first session, the subject was taught how the voiced "b" was felt together with different vowels, cf., the MHS-system (Ekström, Miller, & Öhngren, 1983). Then the visemic sound "p" was trained and exercises in perceiving the differences between "b" and "p" were carried out. "M", the third visemic sound of the labials, was trained thereafter. In the beginning of the training only a few words were accessible but soon after, words and sentences were used that contained the newly learned consonants together with earlier learned ones. All subjects were trained individually, approximately 1 hour at a time. The teacher stopped when the subject reported that he or she could recognize the difference between the sounds. Thus, the first training session consisted of words and sentences based on "b"-"p"-"m", the second session contained exercises with "r", "d"-"t"-"n", the third session "s", "g"-"k"-"ng", in the fourth "l", "v"-"f", "h", and in the fifth and final session, "j", "tj" and "sj" were introduced and trained. Concluding the training procedure, the teacher and the subject had a repetition session after which the subject was informed that the next session would be a test session.

**Test sessions.** After finishing the speechreading and Tactiling training sessions, all subjects' speechreading and Tactiling skills were tested in a live situation. Testing was carried out individually. The distance to the speaker was an arm length in both test situations. During the test session, the subject was given postspeech B/GO/, a parallel version of the speechreading test given as prespeech A/GO/, before the actual training in speechreading started. The subject was also given posttact B/GO/, a parallel version of pretact A/GO/. The order of the tests was counterbalanced. The subjects who started with the prespeech A/GO/ test now took posttact B/GO/ first, and those who started with pretact A/GO/ were first administered the postspeech B/GO/ test. The speaker was
the teacher in Tactiling (GO). When the subject had been tested she/he was asked to return 14 days later and was informed that another test would be given. Upon return she/he was met by a man (BL) – not familiar to her/him. Each subject was now given postspeech A/BL/, that is, exactly the same test as prespeech A/GO/. All subjects were also administered posttest A/BL/, the same as pretest A/GO/. As four months had passed between the pretest A/GO/ and posttest A/BL/, it seemed reasonable to assume that no learning effect specific to the materials could have interfered with the results.

In all test-sessions the subject repeated orally as much as she/he had perceived of the spoken test sentences, and the answers were recorded on tape. The score, for each subject in each test condition, was based on the mean of the proportion correctly perceived words in each of the 24 sentences (Lyxell & Rönning, 1989).

**Design**
The design was a 2x2x3 pretest-posttest, control group, design. The first factor refers to the group variable (experimental group and control group), the second to the communication form (speechreading only and Tactiling), and the third factor to the type of test (pretest A/GO/, posttest B/GO/, and posttest A/BL/). The eight subjects were randomly assigned to the experimental group and to the control group, four subjects in each.

**RESULTS**
The results section constitutes a comparison between speechreading and Tactiling performance for both the experimental group and the control group in the three different test situations: pretest /GO/, posttest /GO/, and posttest /BL/.

A three-way ANOVA on the scores for each subject in each test condition demonstrated two significant main effects. First, a main effect as a function of the communication form was revealed. Tactiling was generally better, $F(1,6)=18.03$, $p<.01$. Second, there was also a significant main effect as a function of the type of tests, $F(2,12)=18.00$, $p<.01$. The results in posttest B/GO/ are better than in both pretest A/GO/ ($p<.05$) and posttest A/BL/ ($p<.01$). The effect of training, that is, the difference between the experimental group and the control group, was not significant ($p>.05$). No significant interactions were obtained. The main results are depicted in Fig. 1.

![Fig. 1](image-url)
For the two-way means based on the communication form and type of test variables (Fig. 1), a Tukey post hoc test revealed significances ($p < .01$) for Tactiling over speechreading, independently of test occasion and person. In addition, the posttact B/GO/ was significantly better than the posttact A/BL/ as well as the superiority of postspeech B/GO/ versus the postspeech A/BL/ test.

Thus, improvement in speechreading as a function of Tactiling is not a method unique to GS. That is, the profoundly hard of hearing individual is able to combine the information from the vibrations in the hand with the talker’s lip movements and face, such that speechreading is improved. This improvement is already present in the pretest scores, and it does not increase as a function of training. The superiority of the familiar speaker /GO/ in all tests, is in accordance with the general experience that hearing-impaired individuals have more difficulties when talking to an unfamiliar person.

DISCUSSION
The results from the present study demonstrate a significant improvement in speech understanding, when speechreading is combined with Tactiling. This improvement is direct, that is, without the need of training. One of the subjects, however, found Tactiling socially unacceptable. In the Tactiling test before training, he got worse result with Tactiling than with speechreading. The other subjects improved the speech understanding with Tactiling. This direct effect of tactile stimulation has also been obtained in experiments with vibrator (Axelson, 1987; Weisenberg, 1989). When Tactiling, the deafened adult takes direct advantage of the vibrations emanating from the vocal tract and can successfully combine this information with the visual information from lip movements. Studdert-Kennedy (1983) states:

"In perceiving speech, we perceive not only its 'kinematics', that is, the changes and rates of change in spectral structure, but also the underlying dynamic forces that produce these changes. In other words, to perceive speech is to perceive movements of the articulators, specified by a pattern of radiated sound, just as we perceive movements of the hand, specified by a pattern of reflected light."

For the deafened adult it is not possible to perceive "the changes and rates of change in spectral structure". When Tactiling, though, the person is able to feel some of "the underlying dynamic forces that produce these changes" directly in his/her own hand.

The study did not reveal any main effect of training. The test material used was simple declarative Swedish sentences, embedded in a contextual scenario. The training material was mainly analytic, and one explanation as to why the experimental group did not show any further significant improvement may be that the training period was too short to be effective. The speech information in the Tactiling signal is probably mainly time-intensity information as the frequency-discrimination ability of the tactile sense is poor (Goff, 1967). The tactile gross time-intensity information can apparently directly, without need of training, be used to supplement speechreading. In order to use finer details in the signal, longer training is probably needed. When learning to use this information in combination with the lip movements, there is even a possibility that – in the beginning of the training period – integrating the tactile and the visual information will "mix up" things for the subject, and she/he may be disturbed by "new" perceptual information from the tactile sense.

Based on the modular theory of Fodor (1983) and Massaro (1987), it could also be the case that Tactiling triggers an input module for speech. A module is characterized by fast, effortless, and encapsulated processing of information. If this automatic processing is facilitated by the direct fusion of visual and tactile information, it may not be
surprising that "training" does not improve modular information processing. Training, aimed at "unencapsulating" a module, may in the initial stage of practice even be disruptive to its function. The data collected in this study cannot shed any light on this hypothesis – but suggest – interesting further research on this hypothetical speech module.

In this study there were two persons involved in the evaluation of training, one person well-known to the subjects (GO) and one not familiar to the subjects (BL). The results were significantly better when the person well known to the subjects administered the Tactiling test. The method – even though it is a good supplement to speechreading – entails some social restraints. If Tactiling is to become a method to supplement speechreading, then it is important that the hard of hearing person learns to touch another person in the communication situation. This might be a problem for a deafened adult, as it is not the normal way to communicate.

Taken together, the information given by the vibrations from the vocal tract offer good complementary information to speechreading. Tactiling makes it possible to use this information also in a noisy, everyday situation where an ordinary vibrotactile aid is more or less useless. We suggest that, for the deafened adult to communicate effectively, there should be a tactile aid that receives signals wireless from a larynx-microphone. The deafened adult could then hand the microphone over to the speaker and ask the speaker to hold the microphone against the larynx when speaking. The larynx microphone would be a substitute for the hand used in Tactiling. The tactile aid would only amplify the vibrations from the vocal tract. No other disturbing noise would interfere with the speechreading process.

A device has been built according to this principle. The device is called Tactilator. A study in which a Tactilator is compared with an ordinary vibrotactile aid supports the hypothesis that a Tactilator will give more support to speechreading than a conventional tactile aid (Öhngren, Kassling, & Risberg, 1990).

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References


