MEASURING SPEECH COMPREHENSION

Robert McAllister & Mats Dufberg
University of Stockholm
Institute of linguistics

1. **BACKGROUND.** In many areas related to the study of language, both theoretical and applied, there is a need for measurements of speech comprehension. Two such areas dealt with in this report are the assessment of functional hearing loss and oral speech comprehension in second language aquisition. As we see it, understanding speech is dependent on two sources of information, signal dependent and signal independent information, respectively. (Cf. top-down and bottom-up, respectively.) The interaction between the two sources is shown in fig. 1. According to this model, the more signal dependent information that is available for the listener the less signal independent information is needed and vice versa. Common audiometrical measuring methods have a bias towards signal dependent information, and the correlation between tone and speech audiometry, on the one hand, and speech comprehension, on the other, is commonly questioned.

Here we will report on a pilot study which is part of a larger study we have recently started, which we will present in McAllister & Dufberg (forthcoming). The aim of this pilot study is to test two available methods and one new method that, at least partly, claim to test speech comprehension. If our model of interaction between signal dependent and signal independent information is correct and it is correct to assume that noise will mask the signal it is reasonable to assume, firstly, that native speakers will be able to stand more noise (that is, lower signal-to-noise ratio) than L2 speakers, secondly, that persons with normal hearing can stand more noise than hearing impaired persons.

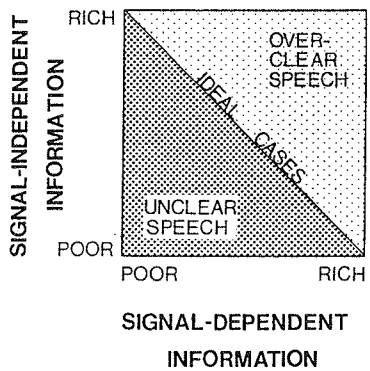

Fig 1. Mutality of speaker-listener interaction. (Reprinted from Lindblom, 1987.)

2. **SUBJECTS.** In this pilot study we used two groups of subjects; one group of foreigners with Swedish as second language who speak broken Swedish, henceforth referred to as L2 speakers, and one group of hearing impaired persons with Swedish as their first language.

The L2 speakers were four persons working at our lab,

three of which are trained phoneticians and the fourth belonging to the technical staff. All four of them speak Swedish well. The group of hearing impaired persons consisted of only two persons. They are both members of the staff of our department. Their hearing loss is fairly severe, 50 to 70 dB. As a control group we used six native speakers of Swedish with normal hearing, all of them members of the department staff.

Both experiment groups have perturbed speech comprehension; the L2 speakers on their ability to use signal independent information, and the hearing impaired persons on their ability to use signal dependent information. We regard measuring functional hearing loss and testing speech comprehension in language learning being special cases of measuring speech comprehension.

3. **METHODS.** In this study we tested three related methods. The first method is one designed by Walker & Byrne (1985). In this method the subject is listening to a text and asked to set a noise level so that s/he can only barely follow the text. The signal-to-noise ratio at this threshold level of comprehension is taken to be the measure. This method has been successfully used by A. Risberg and M. Dahlquist with relatively high level of reliability (personal communication). In the following we will refer to this method as the Threshold method.

The second method is similar to the first. Instead of letting the subject choose the noise level s/he pressed a button which gave an increasing noise level. When the subject released the button the noise level fell to a minimum. The instruction to the subject was to press the button and to release it when s/he could not follow the text. The method has also been tested by Risberg and Dahlquist who report that it is less reliable and has a greater learning effect than the Threshold method (personal communication). In the following we will refer to it as the Ramp method.

With our third method, which to our knowledge has not been tried before, we tried to create a less unnatural situation where comprehension really is tested, not the subjective impression of comprehension. We presented questions in noise to our subjects and asked them to answer the questions. When they gave a correct answer we increased the noise level one decibel and in the case of an incorrect or no answer we decreased the noise level one decibel. The questions presented were so called Helen questions (Ludvigsen 1975) which anybody speaking Swedish would know the answer to. ("What color is a lemon?" etc.) We took the signal-to-noise ratio at a correct answer after an incorrect one (that is when we had decrease the noise level one decibel) as the measure of this method. We will refer to it as the Helen method in the following.

The noise we used in this study had the same long time spectrum as male speech and was low frequency modulated. It is the noise described and used by Hagerman (1984). We assume that

It fairly well matched the male voice we used for our speech material.

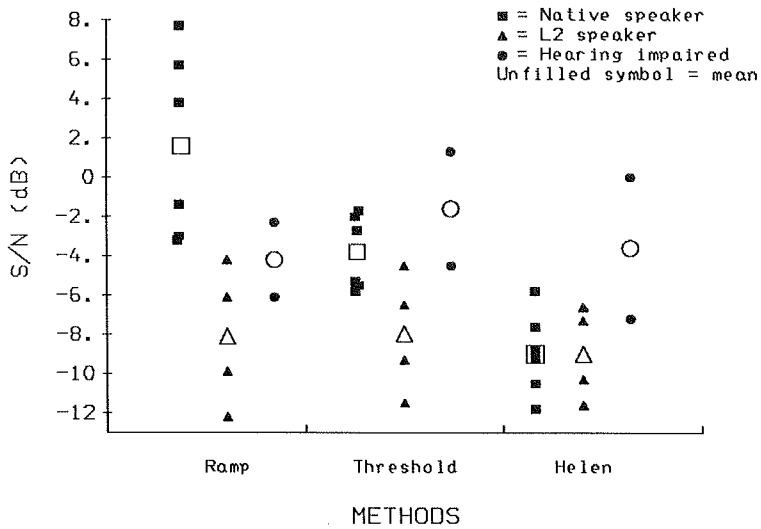

Fig 2. In the figure a filled symbol represents the mean of a few repetitions of one subject. Each subject is represented three times in the figure: once for each test method. An unfilled symbol represents the mean of the test group for each test method.

4. RESULTS. In figure 2 the results of our study are presented. If we can assume that the Helen method is more valid for testing speech comprehension and that our speech material for the different tests are comparable, we can conclude that native speakers seem to underestimate their speech comprehension in noise. (Compare squares for the three methods. Note that the decrease on the S/N scale indicates more noise.) The L2 speakers, on the other hand, seem to be more accurate in their estimation (triangles). The hearing impaired group (circles) is too small to let us draw any conclusions, but we can notice that one of them is not worse than the control group.

Let us finally compare the results for the three test groups for the Helen method. The means of the control group and the L2 speakers are identical. All L2 speakers are in fact within the control group. One of the hearing impaired is also within the control group, the other is well above.

5. DISCUSSION. For two of the methods, the Threshold and the Ramp methods, the relationship between test result and speech comprehension is at best indirect. Firstly, we cannot assume

that all subjects have the same criterion for deciding that they can only barely follow the text or cannot follow the text. Secondly, both tasks are very different from normal speech interaction. The Helen method, on the other hand, involves no subjectivity. What is measured is the ability to do the task, i.e. answering the questions. If you have not heard the question you cannot guess, and if you have heard it you will certainly be able to answer it. But there are certainly problems with the speech material we used in the Helen method, i.e. the Helen questions. Firstly, they are very predictable in form (just wh-questions), secondly, it is very limited what they question (color-of, opposite-of etc.). These two factors make the risk of learning quite high.

In figure 2 we can, firstly, see that the L2 speakers can stand more noise than the control group for both the Threshold and the Ramp methods. We suggest that L2 speakers are more used to low comprehension level and therefore have a lower requirement for what they consider to be their subjective threshold. Secondly, and more surprisingly, it seems like the noise has the same effect on speech comprehension for native speakers and L2 speakers, assuming that the Helen method really tests speech comprehension. Such an result is clearly counter intuitive. Both authors of this report clearly feel that they are more sensitive to noise in L2 than L1 situations, and that is a widespread view as far as we know. (One suggestion is that the noise type is very special. In our forthcoming paper we will report from studies with a different noise type.)

6. CONCLUSIONS. In this study we cannot see that second language speakers are more sensitive to noise masking than native speakers, which contradicts our expectations. We cannot as yet give any reasonable explanation for the result.

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