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COMPUTERIZED CLASSIFICATION OF AUDITORY TRAUMA:  
RESULTS OF AN INVESTIGATION ON SCREENING  
EMPLOYEES EXPOSED TO NOISE

Ingmar Klockhoff

Translation of "Horselskadeklassifikation med dator:  
Undersokningsresultat fran screening pa  
bullerexponerad personal," Audio-Nytt,  
University Hospital, Uppsala, Sweden,  
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16. Abstract With the aid of automatic, computerized classification of results from a screening of employees exposed to noise, we have obtained a fast and effective method of identifying and taking measures against auditory trauma. This technique also satisfies the urgent need for quick discovery of cases which deserve compensation in accordance with the Law on Industrial Accident Insurance. Unfortunately, use of this method increases the burden on the already overloaded investigatory resources of the auditory health care system.					
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Propaganda and a mounting concern about occupational safety /((10)\* and health have resulted in an increase in mass examinations of noise-exposed employees using auditory screening, which is a simple, fast, and easily understood method. The problem is that the majority of the employees have auditory defects, particularly high-tone impairments, of such a type that it may be a question of noise injury and should thus be treated accordingly.

The number of measurement results continuously accumulating from industry needs sorting and evaluation as quickly, uniformly, and inexpensively as possible. There is pressure on business administrations to get this done. The persons examined also want information about their hearing: the Law on Industrial Accident Insurance allows compensation in the form of a life annuity if the hearing loss is estimated as corresponding to 10% disability, and if it can be reasonably determined that the impairment is the result of an occupational injury. However, the annuity can only be paid out retroactively over 2 years from the date when the case was registered with the State Insurance Bureau.

There is, thus, a rush to get the injury claims under examination and the cases deserving compensation registered.

Our Method

Because of this, since about 1970, our group here in Uppsala has been developing an automatic system of classification, which

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\*Numbers in the margin indicate pagination in the foreign text.

makes it possible for the non-specialist company physician to understand and be able to handle the occurrence of hearing injuries with little need for consultation with the specialists in the field, who number far too few to be able to manage the amount of work accumulated. As a basis for the system, we have designed a form on which it is possible to indicate by small pencil marks such items as personal data, date of examination, place of work, occupation, etc., as well as the hearing impairment found in the right and left ears when measured at the most common frequencies, in our case, ranging from 500 to 6000 Hz.

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If the company physician so wishes, he can also enter various data in an interview section at the bottom of the form, concerning matters of interest in this connection: what form of noise is--or was--the person in question exposed to; has hearing protection been used or not, and in the latter case why not; is there any indication of auditory disease or hearing impairment in the family of the person questioned; any vertigo, subjective complaints, etc. The most necessary and important thing is, thus, personal data and information on hearing loss, and completing this form is the only manual activity required for automatic classification and printout of the results. The forms can be mailed to a computer center and there placed in an optical scanner which reads the pencil marks and transfers all the observations to magnetic tape. The tape is then fed into the computer, which is programmed to convert the auditory data into a 2-digit injury

Employees in industry who are exposed to noise are being examined in increasingly large numbers.

number for each individual. The first digit describes the hearing in the right ear, the second, that in the left ear. The injury digits for each ear are graded 1-5, and the computer can handle this grading itself, because it is programmed to decide the relationship of the measurement data to different areas on a pure-tone audiogram sheet. These "area conditions," which form the basis of the computer's capacity to characterize the hearing impairment in one ear by one of the five injury digits, are illustrated in Fig. 1, demonstrating our criteria for hearing impairment.

Digit 1 means that there is no noteworthy hearing impairment in that ear with respect to the present practical situation.

Digit 2 covers all hearing impairment in the high-tone field, limited almost exclusively to the frequency range 4000-6000 Hz. Such an ear has no hearing difficulties, but there may exist very ugly high-tone defects which should be diagnosed and treated to prevent further deterioration.



## Aspects of Practical Applicability

If an individual obtains the injury digits 23, it means, thus, that in his right ear there is a symptom-free defect in the high-tone area of the 4000-6000 Hz range, and in his left ear, the high-tone impairment has made inroads on the 3000 Hz range. He may therefore suffer some hearing difficulties in that ear in an acoustically difficult environment. It is, of course, among those who obtain injury digits 44 that it becomes necessary to decide whether the impairment is serious enough to correspond to at least 10% disability and thus, the State Insurance Bureau must be notified. Recently, a criterion has been distributed within the Industrial Safety and Health Organization regarding the amount of impairment at different measuring frequencies and at what level an individual should be reported as suspected of suffering from an occupational injury which requires compensation. These pure-tone audiometric criteria have been fed into the computer. When the computer discovers an individual with the digits 44, a number regarded as corresponding to 10% disability, it immediately prints out "Notify the State Insurance Bureau of indication of compensatory occupational injury." In such a case, the computer also prints out the digits on hearing loss in each ear at all six frequencies tested. For all others, the computer always prints out, for each individual, the so-called "pure-tone mean" at 500, 1000, and 2000 Hz, followed by the "high-tone mean" at 3000, 4000, and 6000 Hz, first for the right ear, then for the left. In this manner, there is one line for each person in the automatic printout, starting with the personal identification number, designations of work place, area, occupation, and date of examination. Then follows the two-digit injury number and the figures on hearing impairment mentioned above. It is easy to remember the meaning of the injury digits, and with the additional information given by the "impairment means," a proper understanding is obtained of the situation in each individual case, with respect both to injury and to the

level of hearing. All of this is easy for the Industrial Safety and Health Organization to handle, as it is arranged in a distinct fashion and is low in cost. Only a few days after the forms have been mailed, the printout is returned by mail in the form of a neat booklet, in which some twenty persons are accounted for on each page. When there are forms for about 1000 individuals, the time under the optical scanner amounts to about one hour, but the entire classification process, including the printout by the computer, is done in less than one minute. The entire classification process, including the cost of the forms, amounts at present to about 0.45 Swedish Kronor per person.

The intention is, thus, that the company physician obtain control over the injury situation by more or less direct co-operation with a computer center where there is an optical scanner able to read the forms. This is the case at the Uppsala Data-central (UDAC: Uppsala Computer Center).

### Another Variation

Our method of designating hearing impairment using digits and automatically computerized classification, based on the position of the data measured on a pure-tone audiogram, has been adopted and modified for the occupational-audiological activities at Sahlgren Hospital [Stockholm]. There, information is requested also for the frequency ranges of 250 and 8000 Hz, and the requirements are more stringent (by 5 dB) when it comes to exemption from hearing impairment. The criteria have also been expanded by sub-groups, so that each ear has a 2-digit designation. An individual will thus be described by a 4-digit number. Due to the many combinations possible in this system, there will be a large number of injury categories, and these will be fairly hard to survey. Practical application of our own system has given us the impression that the designation by a 2-digit injury number makes possible a comprehensive overview

and a satisfactorily exact grouping of the individuals. In addition, mandatory supplements regarding certain pure-tone audiometric-loss values furnish sufficiently detailed acuity in individual cases.

#### Some Formal Directions

The business enterprises desiring to use our system can request the forms necessary for hearing measurement which can be read by the optical scanner from the Central Purchasing Organization of the County Councils, Department of Forms, 171 83 Solna. The number of the form is LIC H-10 1975-04. A pamphlet will be included, describing how to complete the form.

However, medical conditions must not be subjected to automatic computerization without permission from the Computer Inspectorate. A very comprehensive account on our part has paved the way at the Computer Inspectorate, so that, in future, businesses can obtain permission with a very brief application form, referring to the orientation we have furnished about our classification system.

Some of the conditions set by the Computer Inspectorate are that there must be someone responsible for the record, who sees to it that those examined are informed that their hearing data will be subjected to computerization and that they have a right to demand exclusion from the record if they so desire.

#### The Reverse Side of the Technique - The Increased Load on Audiology

The application of computerization has been damned in many cases, and with good reason. In our case, the advantages and praiseworthiness of the system cannot be questioned. What is being done is intended to discover and to halt the progress of occupational injury when it is found to be reasonable. The Industrial Safety and Health Organization has thus obtained a

very efficient tool for coming to grips with the injury problem; but, unfortunately, the efficiency of the system has dire consequences for the otological and audiological clinics in this country, and the waiting lists for the investigatory work necessary according to the Law on Industrial Accident Insurance and the Regulations on Military Claims for Compensation are already very long. When using an automatic system of classifica- /((16)) tion of this type, the load increases by leaps and bounds to almost unmanageable proportions. In 1975, when Bygghalsan [Organization for Health in the Construction Industry] applied this classification method with its inherent demand of finding the 10% disability to 120,000 workers, there resulted a simultaneous registration of about 4,000 cases with the State Insurance Bureau. As is well known, each case requires a rather comprehensive inquiry, under the direction of the State Insurance Bureau, before the individual case is forwarded to the department for evaluation of disability; this ultimately may lead to a monthly compensation of varying amount, according to the percentage of disability estimated by the different calculations--if it really is a question of occupational injury. So far, it is only "the more serious 44's" who have been accepted for this treatment. Figure 2 shows the distribution of the injury numbers in data from about 3,000 construction workers, who were screened under the supervision of the Malmo office of Bygghalsan. The injury numbers are printed in the far left column, and both total distribution and distribution by age groups can be seen. It is evident that only 4.7% are "44" cases, and among these, about half warranted registration. The impression is that, in a typically noisy industry, 2-3% of the cases can be registered according to presently valid principles; these cases still lead to a work load very difficult to handle. But worse is in sight: on the labor market there has recently appeared an especially comprehensive insurance contract, the AMF Insurance Agreement, which is a "security insurance" intended to compensate for

The occurrence of two-digit hearing impairment numbers among 2,932 construction workers.

Hearing impairment number	Age distribution			
	-30	31-40	41-50	51-
11	944 (32.2%)	180 (29.0%)	58 (9.7%)	35 (5.9%)
12,21	522 (17.8%)	159 (25.6%)	99 (16.6%)	49 (8.3%)
22	605 (20.6%)	145 (23.4%)	185 (31.0%)	163 (27.5%)
13,31	25 (0.9%)	10 (1.7%)	7 (1.2%)	2 (0.3%)
23,32	227 (7.7%)	37 (6.0%)	82 (13.7%)	69 (11.6%)
33	133 (4.5%)	27 (4.4%)	42 (7.0%)	46 (7.8%)
14,41	33 (1.1%)	4 (0.6%)	5 (0.8%)	5 (0.8%)
24,42	114 (3.9%)	18 (2.9%)	34 (5.7%)	53 (8.9%)
34,43	60 (2.0%)	4 (0.6%)	18 (3.0%)	35 (5.9%)
44	137 (4.7%)	11 (1.8%)	35 (5.9%)	79 (13.3%)
15,51	22 (0.8%)	10 (1.7%)	4 (0.7%)	1 (0.2%)
25,52	30 (1.0%)	4 (0.6%)	10 (1.7%)	12 (2.0%)
35,53	12 (0.4%)	2 (0.3%)	3 (0.5%)	6 (1.0%)
45,54	37 (1.3%)	4 (0.6%)	6 (1.0%)	23 (3.9%)
55	31 (1.1%)	5 (0.8%)	9 (1.5%)	15 (2.5%)
2 932 (100%)	1 122 (100%)	620 (100%)	597 (100%)	593 (100%)

Fig. 2.

practically every small deviation from any normal body function if it can be declared the result of an occupational injury. This means that there can be compensation possibilities also for hearing impairment of disability less than 10%. In this case, there must also be investigations and evaluations of disability for the less serious "44's" and, in addition, for the "33's" and, of course, the combinations of these digits, i.e., the "34's" and the "43's." As can be seen from the table, there will then be an enormous increase in the case-load to be investigated, and it will be no easy task to make suggestions as to how all this should be handled.

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