A Database Management System for the Communication Profile for the Hearing Impaired

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Hand scoring of self-assessment inventories is both time consuming and error prone. Automated scoring systems that use dedicated microcomputers and database management systems provide fast, reliable scoring, and also facilitate data retrieval. As an example of this approach, a database management system for the Communication Profile for the Hearing Impaired is described.

Self-assessment inventories are becoming increasingly popular in rehabilitative audiology, because they provide clinicians with information about patients' communication problems that is not reflected in audiometric measures. If score interpretation is based on patients' responses to individual questions, the self-assessment instrument functions like a standardized clinical interview and its validity may be assumed; i.e., it is assumed that patients respond truthfully when questions are asked in a face-to-face format.

One problem with self-assessment inventories is that they can be very time-consuming to hand score. The Hearing Performance Inventory (Giolas, Owens, Lamb, & Schubert, 1979; Lamb, Owens, & Schubert, 1983), contains 90 5-point items that provide scores on several scales and the Hearing Measurement Scale (Noble & Atherley, 1970) contains 42 items organized into seven areas. If scoring templates are not available, clinicians must develop their own procedures for hand scoring. Another disadvantage is that hand scoring is subject to clerical errors. If an assessment technique is

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more time-consuming to score and more subject to error than the clinical interview it is designed to replace, it is unlikely to be widely used.

Automated scoring offers a double advantage as it is both efficient and reliable. There are many ways to implement automated scoring. If a mainframe computer is available, scoring programs can be written in FORTRAN or another high-level programming language. Alternatively, a statistical package such as SPSS (Hull & Nie, 1981; Nie, Hull, Jenkins, Steinbrenner & Bent, 1975), BMDP (Dixon, 1981), or SAS (Helwig & Council, 1979) may be programmed to do the scoring. For several reasons, neither of these solutions is optimal. First, the hardware and software are not readily available to all clinicians. Second, even when a mainframe computer is available and has been appropriately programmed, it must be shared with other users. Time-sharing means that during peak usage it may be difficult to access the computer. Use of telephone line connections to the mainframe creates other problems such as monopolizing the phone line while the computer is in use and being accidentally cut off if someone breaks into the line.

Our experiences at Walter Reed illustrate these problems. Over the past three years we have been developing a self-report inventory called the Communication Profile for the Hearing Impaired (CPHI). It contains 145 items that yield a profile of scores on 25 scales. These fall into four broad areas important to aural rehabilitation: Communication Performance, Communication Environment, Communication Strategies, and Personal Adjustment. Profiles are used in individual counseling and in group discussions of communication and adjustment problems.

During the development and pilot testing of the CPHI, raw data was entered via a video terminal that communicated over telephone lines with a mainframe computer. Because the data was being used primarily for research, it was processed using SPSS. Later, a specially written FORTRAN program scored the CPHI responses. In both cases the scores were displayed on the terminal screen, and the clinician copied and plotted the scores on graph paper by hand. Clearly, such a system would not be efficient for routine clinical applications.

The alternative that was adopted is one that is readily available and relatively inexpensive. In addition to solving the test-scoring problem, it has also provided possibilities for data retrieval that have exciting clinical applications. It would, therefore, be useful even with relatively short and easily scored inventories such as the Hearing Handicap Scale (High, Fairbanks, & Glorig, 1964) or the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982). The hardware portion of the solution is a dedicated microcomputer; the software solution is a commercially available database management system that is adapted for use with the CPHI.

WHY A MICROCOMPUTER?

The main reason for using a microcomputer is that it can be acquired at a reasonable cost (less than $2000), yet it has the power to perform its intended function with only a small investment in program development. The problem of access is solved because the computer can be dedicated to just one application, if necessary.

The computer being used is a XEROX 820-II. It has an 8-bit Z-80 microprocessor with 64K memory and two 8-inch, single-sided, double-density floppy disk drives, each with an available storage capacity of 482K bytes (or 493,568 characters). The monochrome monitor displays 24 lines and 80 columns of characters, each formed within a 5 × 7 dot matrix. It uses the popular CP/M operating system and can run any CP/M software that is available on 8-inch disks.

WHY A DATABASE MANAGEMENT SYSTEM?

A database management system is a program that is designed to aggregate and manipulate large quantities of data. It can be used for administrative processing (such as scoring responses and printing profiles), and it can also be used for research applications.

A database is a set of records each of which contains several fields of information. In the present context each record would contain fields of data for a single patient. Each field has a name, a width, and a data type (e.g., numeric or character). This information determines the structure of the database. Records are entered into the database as they become available. At any time, information can be retrieved from the database, either for a single record, for all records, or for records that meet certain criteria. Fields can be listed, graphic displays can be designed, and summary reports can be generated.

Many commercially available database management systems perform these basic functions by means of a command language. Thus, a database management system is similar to a programming language; in order to make the system execute desired operations, someone must learn the language for communicating with that system. However, the level of programming skill necessary to accomplish this is considerably less than would be needed to program the entire system from scratch. In addition, many database management systems are written in machine language. This makes them considerably faster than programs written in more popular languages such as BASIC. Thus, with only a small investment in programming, it is possible to customize the system for a particular application so that those using the system are not required to learn the database command language at all.

One goal for the CPHI was to develop a program that could be copied and shared with users having compatible hardware and the database software. The database management system selected for the CPHI is called dBASE II.

DBASE II is available for nearly all popular personal computers provided they have a minimum of 48K - 56K memory. Database files can contain 65,535 records and each record may contain up to 32 fields of 254 characters each, but no more than 1000 characters in all. Numerical operations have 10-digit accuracy. To take full advantage of dBASE II's capabilities, the computer system can be upgraded with a hard disk, but for most clinical applications this would not be necessary. The current list price for dBASE II is $495, but it can easily be obtained for less than $300.

The CPHI database system was designed with several objectives in mind. First, the audiologist should have to learn as little about the dBASE II language as possible. To achieve this, a menu-driven system was developed. At each step, the user is given a list of alternative actions that may be taken and is instructed how to respond. Also, there is a User's Manual that describes the system in detail and gives instructions on its use. Second, it should accept raw data, generate the 25 scale scores, and produce a readily interpretable score profile for each patient. Third, it should be possible to retrieve additional information that might be of interest to the audiologist after seeing a patient's profile.

The CPHI Menu shown in Figure 1 lists the processing options currently available. Option 1 permits entry of new patient records. When this option is selected the video screen is cleared and a labeled format for entering the data is displayed. Background information for this population includes name, test date, sex, duty status, service, rank, date of birth, and a code for educational level. Age is calculated from the test and birth dates. Because dBASE II is limited to only 32 fields, each column of responses from the answer sheet is entered as a single field.

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*************
* CPHI MENU *
*************


OPTIONS

   1...ENTER NEW RECORDS
   2...REVISE OLD RECORDS
   3...DELETE RECORDS
   4...PRINT PATIENT LOG
   5...SCORE PROFILES ONLY
   6...PRINT PROFILES ONLY
   7...SCORE AND PRINT PROFILES
   8...SHOW RESPONSES TO CPHI ITEMS
   9...SEARCH FOR RECORDS AND LIST FIELDS
  10...TERMINATE RUN

ENTER OPTION NUMBER:
```

Figure 1. Monitor display of the CPHI Menu.

Option 2 permits the user to modify records previously entered. For example, typing errors can be corrected and missing data can be added. This type of editing facility is an integral part of database management systems. Option 3 permits records to be deleted from the database. This option is useful when patients' responses are entered solely for the purpose of obtaining profiles and permanent inclusion in the database is not desired.

Option 4 prints a log of patients currently in the database. The log is an example of data retrieval; selected fields are listed for all patients in the database. In this case the log lists five fields: name, test date, duty status, service, and rank.

Options 5, 6, and 7 are used to score the CPHI and/or print profiles. Option 5 calculates the 25 scale scores for one or more patients and stores the results in the database along with the raw data. Option 6 generates a printed profile for one or more patients. Option 7 combines these two functions by scoring and then immediately printing the profile for one or more patients. One drawback of dBASE II for this application is that it is relatively slow at computation. It takes about 2.5-3.0 minutes for the program to score and print one CPHI profile. For this reason, the program separates data entry from scoring and profile generation. This permits audiologists to enter a batch of data and then leave the machine unattended while it performs the scoring and prints the profiles.

A sample profile for a patient in the aural rehabilitation program is shown in Figure 2. All scores are average ratings on 5-point response scales. The 22 profile scales are scored so that high scores are considered desirable and low scores are considered undesirable. The graphic portion of the profile plots the scores, rounded to the nearest fifth of a point. The slashes, also rounded, show the mean plus and minus one standard deviation. This gives a norm for the Walter Reed population that is useful in explaining and interpreting patients' scores. If the scores are normally distributed, this range would encompass approximately the middle two-thirds of the population. Scores below this range are therefore interpreted as relatively low.

After audiologists examine patients' profiles, they may want more detailed information about responses for a given scale. For example, in Figure 2, scores on the Personal Adjustment scales are high, but the score on Denial is low. The audiologist might want to examine how the patient responded to the individual items of the Denial scale. Option 8 provides this information.

As shown in Figure 3, the items of the Denial scale describe common reactions to communication problems that are probably experienced at one time or another by all persons with hearing loss, and even by those with normal hearing. The items are intended to elicit agreement. Because they use the term "sometimes," disagreement is tantamount to stating that these reactions *never* occur, which is unlikely. This patient, for example, disagrees with 7 of the 8 items in the scale.

Examination of responses to individual items has several advantages and it

```
           **************************************************
           *                                                *
           * COMMUNICATION PROFILE FOR THE HEARING IMPAIRED *
           *                                                *
           **************************************************

                          PATIENT NUMBER:   120
NAME:                                                  TEST DATE:  20 MAR 84

COMMUNICATION PERFORMANCE
-------------------------                                      SCORE

                    IMPORTANCE                         1....2....3....4....5

   SOCIAL               3.3        2.7                 I     /  *   /        I
                                                       I                     I
   WORK                 4.0        2.5                 I        *      /     I
                                                       I                     I
   HOME                 3.7        2.7                 I       /*    /       I
                                                       I                     I
   CONDITIONS:                                         I                     I
                                                       I                     I
      AVERAGE                      3.1                 I         / *    /    I
                                                       I                     I
      ADVERSE                      2.2                 I      *      /       I
                                                       I                     I
   PROBLEM AWARENESS               4.5                 I             /    *  I
                                                       I                     I

COMMUNICATION ENVIRONMENT
-------------------------                              1....2....3....4....5

   NEED FOR COMMUNICATION          1.0                 I*    /               I
                                                       I                     I
   PHYSICAL CHARACTERISTICS        3.0                 I    /     * /        I
                                                       I                     I
   ATTITUDES OF OTHERS             4.2                 I         /      *    I
                                                       I                     I
   BEHAVIORS OF OTHERS             4.2                 I          /     */   I
                                                       I                     I

COMMUNICATION STRATEGIES
------------------------                               1....2....3....4....5

   MALADAPTIVE BEHAVIOR            4.7                 I           /     /*  I
                                                       I                     I
   VERBAL STRATEGIES               4.3                 I     /      /   *    I
                                                       I                     I
   NONVERBAL STRATEGIES            4.3                 I         /      *    I
                                                       I                     I

PERSONAL ADJUSTMENT
-------------------                                    1....2....3....4....5

   SELF ACCEPTANCE                 4.6                 I       /        / *  I
                                                       I                     I
   ACCEPTANCE OF LOSS              4.3                 I        /        *   I
                                                       I                     I
   ANGER                           4.5                 I      /       /   *  I
                                                       I                     I
   DEFENSIVENESS                   4.0                 I      /      / *     I
                                                       I                     I
   GUILT                           3.8                 I     /      / *      I
                                                       I                     I
   DISCOURAGEMENT                  4.7                 I       /       /  *  I
                                                       I                     I
   STRESS                          4.4                 I     /        /  *   I
                                                       I                     I
   WITHDRAWAL                      4.1                 I      /        /*    I
                                                       I                     I
   DENIAL                          2.1                 I      */       /     I
```

Figure 2. Printout of the CPHI profile for a patient in the aural rehabilitation program. (Note: Because the printer will not overprint two characters, the slash is suppressed whenever it would coincide with the asterisk.)

```
**************************************************
*                                                *
* COMMUNICATION PROFILE FOR THE HEARING IMPAIRED *
*                                                *
**************************************************

NAME:                                                    TEST DATE:  20MAR84

SCALE:  PERSONAL ADJUSTMENT - DENIAL          (2.1)

ITEM NUMBER                                                          RESPONSE

    90        SOMETIMES I FEEL LEFT OUT WHEN I CAN'T FOLLOW THE
                 CONVERSATION OF THOSE I'M WITH                          2

    91        I SOMETIMES GET ANNOYED WHEN I HAVE TROUBLE HEARING        2

    94        WHEN I HAVE TROUBLE HEARING, I FEEL FRUSTRATED             2

   100        IT'S FRUSTRATING WHEN PEOPLE REFUSE TO REPEAT WHAT
                 THEY'VE SAID                                            3

   102        SOMETIMES WHEN I MISUNDERSTAND WHAT SOMEONE HAS SAID
                 I FEEL FOOLISH                                          2

   122        I SOMETIMES GET ANGRY WITH MYSELF WHEN I CAN'T HEAR
                 WHAT PEOPLE ARE SAYING                                  2

   127        SOMETIMES I FEEL TENSE WHEN I CAN'T  UNDERSTAND WHAT
                 SOMEONE IS SAYING                                       2

   130        I SOMETIMES FEEL EMBARRASSED WHEN I MISUNDERSTAND
                 WHAT SOMEONE HAS SAID                                   2
```

Figure 3. Printout of responses to individual items of the CPHI Denial scale.

is recommended as an adjunct to score interpretation. First, the only type of validity presently claimed for the CPHI is content validity. By continually reviewing the content of each scale, accurate score interpretation is promoted. For example, Denial on the CPHI is operationally defined as a patient's average response to these eight items. It should not necessarily be interpreted as a personality trait, a clinical symptom, or some type of defense mechanism.

Second, by reviewing item responses one can differentiate between patients who earn their scores by responding consistently to most of the items of a scale versus those whose item responses are more varied. For example, a single extreme response on a 5- or 6-item scale can have a marked effect on the scale score. It would be useful to know whether this has occurred and to be able to discuss that particular response with the patient.

A third benefit of reviewing item responses is that clinical impressions about item profiles within a scale may be formed. Certain combinations of responses to items may have diagnostic value that was not apparent from the item analyses performed during test development. Such clinical impressions are actually testable hypotheses that can be evaluated by selectively retrieving information from the database.

Option 9 of the CPHI Menu allows audiologists to search for records in the database that meet certain criteria and to list various fields for those records. For example, two of the Communication Performance scales describe situations that are relatively quiet, versus those where communication is hampered

by noise or by others talking nearby. Most patients have higher scores in the so-called "average" situations than in the "adverse" situations. To identify patients in the minority group for whom performance in average situations is worse than in adverse situations, the search criterion "CPAVER < CPADVER" is entered. CPAVER and CPADVER are the names of the fields. "<" is an arithmetic operator that compares the values of the two fields and selects a record if the comparison is true. The fields to be listed are then specified: NAME, AGE, EDUC, RANK, CPAVER, CPADVER, and PROBAWAR. The three demographic variables are listed for descriptive purposes, and CPAVER and CPADVER scores are listed so that the magnitude of the difference between them may be examined. PROBAWAR is a scale that assesses patients' awareness of common communication problems. It is similar to the Denial scale, except it deals with communication per se, and not patients' reactions to communication problems. It is included to determine whether those who claim to perform better in adverse conditions also score low on Problem Awareness. From the listing obtained (see Figure 4), it appears that generally the difference between the two communication scales is small and that no significant difference between the two types of situations is being reported. For the six patients whose scores differ by more than .5,

```
FIND PATIENTS WHOSE COMMUNICATION PERFORMANCE IS BETTER IN ADVERSE CONDITIONS

                              SEARCH CHITERIA
        .....................................................................
        :CPAVER < CPADVER                                                   :
        :                                                                   :
        :                                                                   :
        :                                                                   :
        .....................................................................

FIELDS TO BE LISTED:  NAME AGE EDUC RANK CPAVER CPADVER PROBAWAR

00005  PATIENT #5                    59.92  7 O6  1.75  2.60  4.37
00013  PATIENT #13                   40.70  2 E7  2.50  2.70  2.50
00048  PATIENT #48                   19.98  2 E2  3.37  3.40  3.50
00077  PATIENT #77                   30.74  2 E5  3.25  3.50  4.37
00090  PATIENT #90                   35.28  4 O4  2.37  2.60  4.00
00093  PATIENT #93                   32.51  2 E6  2.75  3.60  3.87
00101  PATIENT #101                  45.20  2 E7  1.75  2.30  4.25
00113  PATIENT #113                  35.45  3 E6  2.37  2.40  3.75
00114  PATIENT #114                  32.76  2 E5  2.00  2.80  4.50
00116  PATIENT #116                  33.10  3 E7  1.75  2.70  3.87
00122  PATIENT #122                  31.61  2 E6  2.62  2.80  4.12
00129  PATIENT #129                  18.64  2 E3  3.12  4.10  3.87
00130  PATIENT #130                  39.20  2 E6  1.62  1.90  3.50
```

Figure 4. Printout generated by searching the database for patients whose score on CPAVER is less than their score on CPADVER. Fields listed include NAME, AGE, EDUC, CPAVER, CPADVER, and PROBAWAR, in that order. Patients' actual names have been replaced with their respective record numbers. (Note: The data format is fixed and is determined by field width; with additional programming a more readable printout could be designed.)

however, there is no indication that Problem Awareness is low. The next step might be to examine their responses to the individual items of the two scales. Such interactive querying of the database can be used to test clinical intuitions and to explore relationships among variables in the database.

SUMMARY AND CONCLUSIONS

The CPHI database system currently permits (a) raw data to be entered and edited, (b) records to be deleted, (c) a log of all patients to be printed, (d) profiles to be scored and printed, (e) responses to individual items of a scale to be listed, and (f) fields for selected records to be listed. These options are adequate for routine data processing and retrieval. However, the dBASE II system and others like it (e.g., the new dBASE III) have even more sophisticated capabilities. For example, another database containing patients' audiometric records could be defined and dBASE could be used to select records from one database using search criteria defined on the other database. Also, a database could be created for follow-up scores on the CPHI obtained either at the end of the aural rehabilitation program or after a longer period of adjustment to amplification. Report forms for summarizing, as well as listing data could be defined. This capability could be used to generate local norms on the CPHI for a given clinic or to obtain norms for selected subgroups of patients. Similar programming for other self-assessment inventories being used clinically is obviously feasible. Implementing additional features such as these will enable the full potential of the inventory as a clinical tool to be realized.

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REFERENCES

Dixon, W.J. (Ed.). (1983). *BMDP statistical software.* Berkeley: University of California Press.

Giolas, T.G., Owens, E., Lamb, S.H., & Schubert, E.D. (1979). Hearing performance inventory. *Journal of Speech and Hearing Disorders, 44,* 169-195.

Helwig, J.T., & Council, K.A. (Eds.). (1979). *SAS user's guide, 1979 edition.* Cary, NC: SAS Institute.

High, W.S., Fairbanks, G., & Glorig, A. (1964). Scale for self-assessment of hearing handicap. *Journal of Speech and Hearing Disorders, 29,* 215-230.

Hull, C.H., & Nie, N.H. (1981). *SPSS update 7-9.* New York: McGraw-Hill.

Lamb, S.H., Owens, E., & Schubert, E.D. (1983). The revised form of the Hearing Performance Inventory. *Ear and Hearing, 4,* 152-157.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., & Bent, D.H. (1975). *SPSS: Statistical package for the social sciences* (2nd ed.). New York: McGraw-Hill.

Noble, W.G., & Atherley, G.R.C. (1970). The Hearing Measure Scale: A questionnaire for the assessment of auditory disability. *Journal of Auditory Research, 10,* 229-250.

Ventry, I.M., & Weinstein, B.E. (1982). The Hearing Handicap Inventory for the Elderly: A new tool. *Ear and Hearing, 3,* 128-134.