# Patterns of Auditory Perception Skills in Children With Learning Disabilities: A Computer–Assisted Approach

E. Pressman, D. Roche, J. Davey, and P. Firestone

*The performance of 40 learning disabled boys was compared to a normal control group on a computerized version of the Goldman–Fristoe–Woodcock Auditory Skills Battery. This easily administered computerized assessment correctly identified 92.5% of the learning disabled group and 65% of the normal control children. The results address the positive aspects of computer technology in screening children for being at risk for learning disabilities. Normative data for this assessment tool are also presented.*

From early classic investigations (Myklebust, 1964; Wepman, 1960) to more recent studies of learning disabled children's auditory–verbal and/or visual motor integrative difficulties (Koppitz, 1975, 1977; Weiner, 1969), researchers have generally set out to demonstrate that evidence of a learning disability is manifested in terms of one or more perceptual deficits. Some more highly specialized perceptual skills that have been systematically assessed in learning disabled as compared to non–learning disabled children and proposed as possible contributing factors to the deficits are: auditory memory for speech (Lock & Kurtz, 1975); auditory memory for sequence, also called temporal order perception (Bakker, 1971; Doehring, 1968; Tallal, 1976, 1980); selective attention (Brotsky, 1970; Sabatino, 1969); auditory blending (Knights, Hardy & Cunningham, 1982); and auditory discrimination in noise (Marston & Larkin, 1979). By comparing the overall performance of groups of learning disabled and non–learning disabled on carefully planned experimental tasks assessing the auditory skills listed above, these investigations, for the most part, have shown that learning disabled children performed at a substantially lower level than normal comparison groups on the tasks administered.

The use of the computer as a tool for assessment procedures is a logical outgrowth of the vast amount of computer technology now available. In the allied health professions, computer–administered diagnostic programs for use with adults have become increasingly popular (Kleinmutz, 1975). The application of a computer–aided interviewing tool in conducting comprehensive behavioral assessments has also demonstrated its value in saving time for collecting and organizing vast amounts of clients' self–report information (Angle, Ellinwood, Hay, Johnsen, & Hay, 1977). Several investigators have reported success with computer–assisted instruction and testing with children in areas of mathematics, reading, science, and general achievement (Atkinson, 1974; Bitzer, Sherwood & Tenczar, 1973; Cooley, 1970; Suppes, Fletcher, Zannoti, Lorton & Searle, 1973). Furthermore, there has been some work carried out in the area of neuropsychological assessment using a computer–administered battery of achievement tests for children (Knights & Cunningham, 1977; Knights & Hardy, 1978).

With an aim to taking advantage of the potential for computer–assisted assessment of auditory receptive language skills, Pressman, Cunningham, Pressman, Brahan, and Henneker (1982) have adapted a select group of subtests from the Goldman–Fristoe– Woodcock (GFW) Auditory Skills Test Battery (1976) for computerized administration. The audio and visual capabilities of the LEK 421 Portable Learning Assessment Terminal made it suitable for administration of such tests. Descriptions of the method of administration and the subtests selected for use from the GFW battery are given in the procedure section below. The present study was designed to investigate the feasibility of using an easily administered and brief computerized system to screen children at high risk for learning disabilities utilizing a selected group of subtests from the Goldman–Fristoe.

## EXPERIMENT 1

The first experiment compared learning disabled and normal–control children on computerized auditory perception tasks.

## Method

**A. Subjects**

Forty learning disabled English–speaking boys, from 7 to 11 years of age, were selected from those referred to the Children's Hospital of Eastern Ontario, Department of Psychology. They were chosen for participation on the basis of a primary diagnosis of learning disability resulting from comprehensive medical and psychological screening and assessment procedures. These children had received a medical examination to rule out primary visual and auditory defects as well as limiting motor handicaps. A preassessment included information collected from the child's school, the Special Services Department of the school board, and also the child's family. A child was considered learning disabled based upon performance on a battery of psychoeducational tests: the Bender Gestalt (Bender, 1938) with Koppitz error scoring (a measure of visual motor integration, Koppitz, 1968), the Visual Aural Digit Span Test (VADS, a measure of inter– and intra–sensory integration and memory, Koppitz, 1977), and two partial measures of intelligence, the Peabody Picture Vocabulary Test (PPVT, a measure of receptive language understanding, Dunn, 1959) and the Raven's Coloured Matrices (a nonverbal measure of reasoning which includes visual perceptual organization, Raven, 1956).

For the purpose of this project, a broad operational definition of learning disabilities that excluded sensory difficulties and general mental retardation was used. It followed the Ontario Ministry of Education's definition of learning disabilities, namely, "disorders in one or more of the processes involved in understanding or using symbols or spoken language. The disorders result in a significant discrepancy between academic achievement and assessed intellectual ability, with deficits in at least one of the following areas: receptive language (listening, reading); language processing (thinking, conceptualizing, integrating); expressive language (talking, spelling, writing); and mathematical computation. Such deficits become evident in both academic and social situations. The definition does not include children who have learning problems which are primarily the result of impaired vision or hearing, motor handicaps, mental retardation, emotional disturbance, or environmental, cultural or economic disadvantage" (Ontario Ministry of Education, 1978.)

A control group of 40 school board and age–matched non–learning disabled English speaking boys were selected randomly from lists of names provided by the principals of 13 regional public and separate schools from which the experimental children were chosen. Control children had no history of learning or behavior problems. Each child's age was within three months of the matched learning disabled boy's age. These children showed no difficulties on the aforementioned battery of psychoeducational tests.

### B. Procedure

a) *Learning Disabled Children*

Each child was tested on five computerized auditory receptive language tasks. Three assessed auditory memory and two assessed the recognition of sounds, in one case as words and in the other case as unfamiliar sounds paired with unfamiliar visual symbols. These five tasks were administered within a maximum of 3 months after each child's individualized psychoeducational assessment. The purpose of this timing was to minimize any developmental changes that might affect the test scores on these tasks. The administrator of these auditory receptive skills tasks was unaware of each child's assigned learning disability subgrouping as determined by the results of the psychoeducational screening.

The learning disabled children were further divided into one of three groups by the psychologist responsible for the psychoeducational assessment (PSR). The groups consisted of children diagnosed as having auditory language problems ($N = 12$), visual motor problems ($N = 14$), or those having diffuse or non–specific learning problems ($N = 14$).

b) *Control Children*

Each control child was initially assessed on the battery of psychoeducational tests. Interestingly, the scores of 21 children who were referred to the project as controls fell one year below their chronological age on at least one of the four psychoeducational screening tests. For heuristic purposes this became an additional group designated "problematic." Time constraints precluded a full psychoeducational assessment of these children.

A brief medical and audiological screening by a pediatrician to ensure that the children were in good health was carried out before participation. Finally, the five computerized auditory receptive language skills tasks were presented to each child.

c) *The Computer–Assisted Testing Procedure*

Five subtests were selected from the Goldman–Fristoe–Woodcock (GFW) Auditory Skills Test Battery (1976) for computerized administration. These tapped auditory memory for recognition, memory for content, memory for sequence, sound recognition, and sound–symbol association. Under computer control, a series of audio tape segments were presented to the child via a random access tape recorder. Each audio tape segment was a unique task. These audio task questions were synchronized with sets of different pictures presented via a random access slide projector. The pictures in each set were the alternative choices for responding to the task. The screen, measuring 18cm by 30cm, upon which the slides are shown, was touch sensitive. The child made a response to the audio segment by touching the screen at the chosen location. The position of this touch was then recorded by the computer as a correct or incorrect response.

The test administrator interacted with the computer via the keyboard of the printer. Involvement during the testing period was mainly supervisory. At the end of the testing session, the child was given an opportunity to play a computerized Star Wars–type game which was developed for this research project. The game format duplicates the auditory skills testing format with audio segments and slides; however, this was a game in which the child's responses were not skill–related, merely chance choices. Immediately after the tests were administered, the tester gave the parents feedback on how their child had performed. At this time, the child received a "Certification of Thanks" acknowledging participation in a scientific research project.

## Results

Table 1 displays the results of the analysis of variance (ANOVA) comparing the

**Table 1**
**The performance of children in each group on the 5 computerized subtests of the GFW battery**

| TEST SUBTEST | Auditory Language | Visual Motor | Diffuse | Control | Problematic | Grand Mean | *F | p< |
|---|---|---|---|---|---|---|---|---|
| 1. Memory Recognition | 43.67 | 46 36 | 47.29 | 54.85 | 48.57 | 50.63 | 5.13 | .01 |
| 2. Memory for Content | 43.08 | 45.21 | 44.14 | 54.63 | 47.57 | 49.03 | 7.97 | 01 |
| 3. Memory for Sequence | 43.75 | 42.00 | 43.57 | 49 83 | 40 86 | 45.29 | 6.60 | 01 |
| 4. Sound Recognition | 48.50 | 53.50 | 51.57 | 52.50 | 50.57 | 51.63 | 0.89 | — |
| 5. Sound Symbol Association | 42.00 | 45.21 | 51.21 | 54.00 | 45 52 | 49.21 | 3.82 | .01 |

*$df = (1,78)$

**Table 2**
**The comparison of *t*-test values between the groups on the GFW subtests**

| | Memory Recognition | Memory for Content | Memory for Sequence | Sound Symbol Association |
|---|---|---|---|---|
| Auditory language vs. diffuse | 2.90* | 0.32 | 0.06 | 2.00 |
| Auditory language vs. visual motor | 0.64 | 0.64 | 0.60 | 0.70 |
| Auditory language vs. control | 10.73 | 4.17 | 2.49 | 3.11 |
| Auditory language vs. problematic | 4.27 | 1 47 | 1.07 | 0.83 |
| Diffuse vs. visual motor | 0.78 | 0.34 | 0.56 | 1.36 |
| Diffuse vs. control | 7.70* | 4.02* | 2.72* | 0.77 |
| Diffuse vs. problematic | 1.17 | 1.18 | 1.06 | 1.40 |
| Visual motor vs. control | 8.65* | 3.61* | 3.40* | 2.42 |
| Visual motor vs. problematic | 2.02 | 0.28 | 0.44 | 0.48 |
| Visual vs. problematic | 7.33* | 3.10* | 4.47* | 2.7* |

*$p<0.01$

performance of the children on the computerized tasks.

The results indicated a significant difference between the experimental, control, and problematic groups on memory recognition, memory for content, memory for sequence, and sound symbol association. A significant difference did not exist on the test of sound recognition. Further analyses consisting of protected multiple *t*-tests specified between which groups the significant difference occurred on each of the 4 tests (Table 2).

These results indicated that memory recognition and memory for content discriminated significantly between the control group and the three experimental subgroups and the problematic group ($p<.01$). Memory for sequence and sound symbol association were not found to discriminate reliably between groups.

The data were then utilized to determine cutoff scores for Tests 1 and 2 that would most clearly separate high and low risk subjects (Auditory Language, Visual Motor, Diffuse). For both tests, a standard score below 58 was the most potent indicator of high risk, while a standard score of 58 or greater predicted low risk. As indicated in Table 3, using both tests together with a standard score of 58 as the cutoff, 92.5% of the experimental children would be classified as being high risk and 65% of the control group as being low risk.

## EXPERIMENT 2

The second experiment served to obtain additional normative data and provide a partial replication of the results of Experiment 1.

## Method

The method section is identical to that of Experiment 1. The subjects consisted of an additional 100 children referred to the project as control children for Experiment 1. The results are presented in Table 4.

## Discussion

The results of the study indicate that the computerized adaptation of the Goldman–Fristoe–Woodcock Auditory Skills Test Battery (1976) successfully distinguished children with learning disabilities from those without such problems. In fact, two of the subtests, memory recognition and memory for content, which require approximately 20 minutes to administer on the computerized assessment, successfully classified 92.5% of the learning disabled children. Unfortunately, 35% of the non–learning disabled children were incorrectly categorized as high risk for learning disabilities and further research will be required to eliminate such high false positive predictions. With some refinement for use with children down to five years of age and enlarged normative samples, the present computerized system could be utilized in a cost effective fashion as part of an early identification screening for learning disabilities.

An intriguing and disturbing finding concerns the children referred by the schools as control subjects. One–fifth of these children were found to score quite poorly on the psychological screening tests. Whether this reflects that school personnel are unaware of many children who have significant learning problems or, less likely, whether there is some

**Table 3**
**Distribution of children as to Risk of Being Learning Disabled based on a cutoff score of Memory Recognition and Memory for Content**

| | high risk | low risk |
|---|---|---|
| Learning Disabled group | 92.5% | 7.5% |
| Control group | 35% | 65% |

**Table 4**
**Mean standard scores and standard deviations on subtests of Memory Recognition and Memory for Content for 100 Control children**

| AGE | TEST 4 $\bar{x}$ | TEST 4 *sd* | TEST 5 $\bar{x}$ | TEST 5 *sd* | *N* |
|---|---|---|---|---|---|
| 7-0 to 7-5 | 51.63 | 11.43 | 58.88 | 3.27 | 8 |
| 7-6 to 7-11 | 56.13 | 8.38 | 54.88 | 8.05 | 16 |
| 8-0 to 8-5 | 59.25 | 6.96 | 55.81 | 6.62 | 16 |
| 8-6 to 8-11 | 56.09 | 8.32 | 52.50 | 6.32 | 22 |
| 9-0 to 9-5 | 57.58 | 10.41 | 50.42 | 7.18 | 12 |
| 9-6 to 9-11 | 54.65 | 9.41 | 53.00 | 6.48 | 17 |
| 10-0 to 10-5 | 53.75 | 6.70 | 61.00 | 5.10 | 4 |
| 10-6 to 10-11 | 50.60 | 2.51 | 50.80 | 5.93 | 5 |

difficulty with the psychological screening battery remains unclear. An alternate hypothesis is that these control children do have the cognitive deficits of a learning disabled child but have, through some compensatory mechanisms, achieved in academic skills despite these disabilities.

This study demonstrates the positive characteristics of computer technology for clinical evaluation of language skills. First, the microcomputer appealed to the interests and intellectual levels of the subjects. Their feedback indicated that they enjoyed working with the computer and proceeded easily through the various tasks. Second, the use of the microcomputer permitted a rigorous standardization of the testing situation and manner of presentation. Third, the computer's potential for detailed data collection and transformation of scores to meaningful test results relieved the tester of tedious scoring procedures. Finally, it was found that assessments could be administered by relatively untrained personnel, thus providing a cost effective and efficient tool. These findings support the continued use of computer–assisted assessments as a valuable tool in the early identification of learning disabilities.

*ABOUT THE AUTHORS*

*__E. Pressman, PhD,__ is with the Children's Hospital of Eastern Ontario and the Department of Oto-Rhino-Laryngology in the School of Medicine of the University of Ottawa. __D. Roche, PhD,__ is with the Children's Hospital of Eastern Ontario and the Department of Psychology of the University of Ottawa. __J. Davey, MD,__ is with the Children's Hospital of Eastern Ontario. __P. Firestone, PhD,__ is the Director of the Child Study Centre and a Professor in the School of Psychology at the University of Ottawa. He is also associated with the Children's Hospital of Eastern Ontario. Address: P Firestone, PhD, Director, Child Study Centre, 10 McDougal, University of Ottawa, Ottawa, Ontario, Canada K1N 6N5.*

*REFERENCES*

*Angle, H.V., Ellinwood, E.H., Hay, W.M., Johnsen, T., & Hay, L.R. (1977). Instrumentation and techniques. computer–aided interviewings in comprehensive behavioral assessment. Behavior Therapy, 8, 745–747.*

*Atkinson, R C. (1974) Teaching children to read using a computer. American Psychologist, 29, 169–178.*

*Bakker, D.J (1971). Temporal order in disturbed readings. Rotterdam, Rotterdam University Press.*

*Bender, L. (1938). Visual motor Gestalt test. American Orthopsychiatric Association*

*Bitzer, D.L., Sherwood, B.A., & Tenczar, P (1973). Computer-based science education. Computer-based education of research laboratory report X–31, Urbana, Illinois; University of Illinois.*

*Brotsky, S. (1970). Auditory figure–ground perception in neurologically impaired children Journal of Auditory Research, 10, 5–10*

*Cooley, W.W. (1970) Computer assistance for individualized education Journal of Education Data Processing, 7, 18–28.*

*Doehring, D.G. (1968). Patterns of impairment in specific reading disability. Bloomington, Indiana. Indiana University Press.*

*Dunn, L.M. (1959). The Peabody Picture Vocabulary Test American Guidance Service Inc Circle Pines, Minnesota.*

*Goldman, R., Fristoe, M., & Woodcock, R.W. (1976). The Goldman–Fristoe–Woodcock auditory skills test battery American Guidance Service Inc. Circle Pines, Minnesota*

*Kleinmutz, B (1975). The computer as clinician American Psychologist, 30(3), 379–387*

*Knights, R.M , & Cunningham, S J. (1977). Automated pediatric interview and educational assessment In D.B. Shires and H K Wolf (Eds.), MEDINFO 77. Proceedings of the Second World Conference on Medical Information Amsterdam: North Holland Publishing*

*Knights, R.M , & Hardy, M.I (1978). A child–computer–teacher assessment and remedial program for children with poor reading skills: Phase III. Research Bulletin No. 14, Psychology Department, Carleton University, Ottawa, Ontario*

*Knights, R M., Hardy, M.I , & Cunningham, S.J. (1982). A computer–assisted approach to assessment and remediation of basic reading skills Research Bulletin, Psychology Department, Carleton University, Ottawa, Ontario.*

*Koppitz, E.M. (1968) The Bender Gestalt test for young children. Volume II, Research and application 1963–1973. New York· Grune and Stratton.*

*Koppitz, E M. (1977). The visual aural digit span test New York Grune and Stratton.*

*Lock, J.L., & Kurtz, K.J. (1975). Memory for speech and speech for memory Journal of Speech and Hearing Research, 18, 176–191.*

*Marston, L.E., & Larkin, M (1979) Auditory assessment of reading underachieving children. Language, Speech and Hearing Sevices in the Schools, 10(4), 212–220*

*Myklebust, H.R. (1964) Auditory disorders in children New York Grune and Stratton*

*Ontario Ministry of Education (1978) Definition of learning disabilities*

*Pressman, D.E , Cunningham, S.J , Pressman, I.S., Brahan, J.W., & Henneker, W.H (1982) Computer evaluation of language skills in children. National Council of Canada ERB 945, NRCC #20926.*

*Raven, J C. (1956). Raven's coloured matrices. The Institute of Psychological Research.*

*Sabatino, D.A. (1969). Identification of neurologically impaired children through a test of auditory perception. Journal of Consulting Clinical Psychology, 33, 184–188.*

*Suppes, P , Fletcher, J.D., Zanotti, M., Lorton, Jr. P.V., & Searle, B.W. (1973). Evaluation of computer-assisted instruction in elementary mathematics for hearing impaired students Instruction for Mathematics Students in the Social Sciences, Technical Report No 200, Stanford University*

*Tallal, P. (1976). Rapid auditory processing in normal and disordered language development. Journal of Speech and Hearing Research, 19, 561–571.*

*Tallal, P. (1980). Auditory temporal perception, phonics and reading disabilities in children. Brain and Language, 9, 182–198.*

*Weiner, P. (1969). The cognitive functioning of language deficient children. Journal of Speech and Hearing Research, 12, 53–61.*

*Weepman, J.M. (1960). Auditory discrimination, speech and reading. The Elementary School Journal, 9, 325–333*