Automated Vision Screening

PHILIP W. JOHNSTON, Ph.D.

MORE than one-half of the total time of school health personnel is spent in vision and hearing conservation programs in States such as Massachusetts, where annual screening of all children is mandatory. Since enormous amounts of labor are required in extensive screening with the methods now generally in use, it is most desirable that other methods of screening children for sensory impairments be devised as soon as possible. Not only is the number of persons to be tested great, but also the testing needs to be made more reliable, as the results of the well-known study conducted by the U.S. Children's Bureau in St. Louis in 1948 have shown (*1*).

Vision screening in recent years has become much more complex. We now speak of testing not only for visual acuity but also for such functions as latent hypermetropia, heterophoria, and color discrimination. Wherever testing is both complicated and mandatory, nurses or technicians spend a good part of their working time in screening. This concentration of effort leads inevitably to fatigue since screening for sensory impairments is extremely repetitive and monotonous when carried out, as is usual, throughout the school day.

Anyone familiar with screening programs in schools will surely agree that the efforts of highly trained professionals are not well spent on such tedious activities. The introduction of mechanized units, which will overcome tester fatigue and provide more consistent, more uniform, and more valid tests of the screened population at a much lower cost per test, is past due.

An automated vision screener, however, in no sense replaces the school nurse. Rather, it enables the nurse to spend more time in more appropriate functions, such as visiting the homes of impaired children, completing arrangements for medical care, and discussing the visual condition of children with classroom teachers.

Automatic Screening Devices

Over the past several years, I have designed several vision screening instruments with varying types of automated presentation of targets. In all these devices, conventional optics are used, in that the devices function as stereoscopes with focal lengths between 8 and 13 inches.

A production model of an automatic screener (*A*) is shown in the figure. This low-voltage unit features the use of integrated circuit components. Previous experimental models have been basically switch and relay devices powered by full-wave diode bridges and operated at substantially higher output voltages. The figure shows the main stereoscopic viewer and an accessory unit which contains response pushbuttons and a slot for the deposit of numbered metal disks. The instrument can present the screenee with a program such as the following one for the Massachusetts Vision Test:

Dr. Johnston is head of child growth and development, division of maternal and child health services, Massachusetts Department of Public Health, Boston.

Number of frame	*Function*	*Eye*	*Direction of E's*
1	VA	L	S
2	VA	L	D
3	VA	L	S
4	+	L	S
5	+	L	D
6	+	L	S
7	VA	R	S
8	VA	R	D
9	VA	R	D
10	Muscle	------	------
11	VA	L	D
12	VA	R	S
13	VA	L	S
14	VA	R	D
15	VA	R	D
16	+	R	S
17	+	R	D
18	+	R	S
19	VA	L	D
20	VA	R	S
21	VA	R	S
22	Muscle	------	------
23	VA	L	D
24	VA	L	S

CODE: VA—visual acuity, +—plus sphere test, muscle—heterophoria test, R—right, L—left, D—different, S—same.

The Massachusetts Vision Test is designed to test three functions—visual acuity, latent hypermetropia, and heterophoria. Visual acuity is tested by presenting pairs of illiterate E's which are all of a predetermined size, such as 20/30. As each pair of E's comes into view, the subject is to press a Yes button on the instrument if the two E's point in the same direction or a No button if the two E's do not point in the same direction. Switching between the two eyes is effected as the sequence proceeds. Success may be defined as an ability to denote the correct orientation of all pairs of E's without error, or the scoring may be programed so that one error per eye is permitted.

Latent hypermetropia is tested by automatically inserting a plus sphere lens in the optical path at appropriate times in the test sequence. If the subject can discern the correct orientation of the E's during this sequence he is, of course, failed. Heterophoria is tested by presenting a green rectangle before one eye and a small red ball before the other. If the red ball is seen to be on the green rectangle, the subject is instructed to depress the Yes button. Otherwise he is to depress the No button. Here, a Yes response is the passing response.

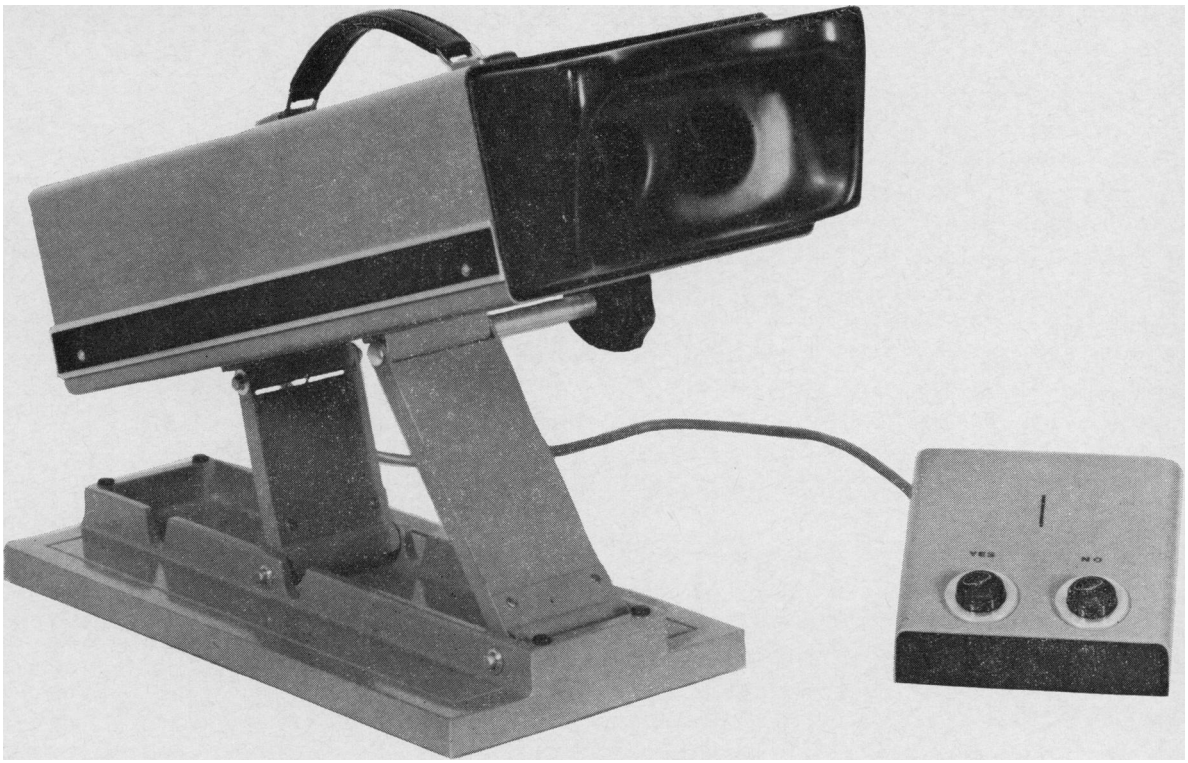
Any other visual function may be tested in ways similar to those described for visual acuity, hypermetropia, and heterophoria by arranging and presenting the stimuli as pairs of targets. Color discrimination, for example, is easily tested by designing color plates so that the subject who is colorblind will have great difficulty, or be unable, to tell whether two illiterate E's imbedded in a stippled color field point in the same direction or not.

Administration of Tests

After a short period of instruction, children can be taught to take their own tests. Self-administration may be accomplished in two or three different ways. One method requires each child, as he comes for his test, to write his name on a form, take a numbered metal disk from a dispenser, and record the number next to his name. The child then begins his test by depositing the metal disk in a slot of the instrument. Each depression of the Yes button or the No button by the child in response to the particular pair of E's in the field of view causes the instrument to frame to the next pair of targets. In this manner the child proceeds through the entire test sequence.

If the responses have been accurate within some predetermined limit, the child's disk is automatically dropped into the "Pass" compartment of a removable drawer. If he has made too many errors, his disk is dropped into a "Fail" compartment. At the end of the school day, the school nurse or other tester needs only to examine the disks in the Fail compartment to determine which children have failed the test.

Before any child is sent to an eye specialist for care, the nurse screens him with the same automatic screener, except that now the screening is monitored. The nurse presses a button to place the targets in view, and the child responds verbally rather than by pushing the scoring buttons himself. Even in the monitored version of the tests, the screening device, rather than the human tester, automatically performs all labor such as occluding and insertion of the plus spheres. In the monitored version, the tester refers to three code lights on the rear of the



Production model of Johnston vision screener—Tracor RA 116

instrument. These code lights, which may be illuminated selectively, indicate the type of stimulus being observed by the child.

The monitored mode of the test, administered by the nurse, is used in kindergarten and grades 1–3. This test can much more readily be given to very young children than conventional tests because the field of view at any one time comprises only two symbols rather than a long line of them. This feature eliminates an important source of confusion. Also, instead of demanding that the child engage in the difficult manual motions normally required in using illiterate E symbols, this method requires the child only to indicate that his response is affirmative or negative.

A negligible number of children attempt to cheat in vision screening tests. Most children with borderline visual acuity, in fact, hesitate to respond to visual targets unless they see the targets very clearly; they must be urged to respond as well as they can. It is of some interest, nevertheless, to calculate the probability of guessing the correct orientation of a series of visual acuity targets. This calculation is made on a worst case basis, in which every child with substandard visual acuity attempts to cheat.

If eight visual acuity symbols are presented and a Yes or No answer is required for each symbol, the probability of correctly guessing the orientation of all eight symbols is 0.004. If one error is permitted in designating the orientation of the eight symbols, the probability of passing by guessing rises to 0.035. For two errors, the guessing probability is 0.144. In practice, these guessing levels may be inflated by a factor as high as 100, since very few children attempt to cheat during vision testing.

Variations in Devices

In automated screening devices, the target may be on rotating film, on slides, or on fixed panels of which parts are selectively illuminated. The plus sphere is presented by the use of rotary solenoid drives. Occlusion may be effected either through mechanical maskers, driven by rotary solenoids, or through the programed extinction of illumination in the area scanned by one eye.

Tests may be scored either by the deposit of numbered disks or by the use of punched cards. In the latter arrangement, the subject writes his name on a small card, which he then inserts into a slot in the side of the instrument. The card contains a set of numbers arranged in a circle. For a test sequence of 24 frames, for example, the numbers are arranged like the face of a 24-hour clock. Each time that the subject makes an error, a punch is driven through the corresponding frame number so that, at the conclusion of the test, the examiner can tell by inspecting the holes in the card which frames caused the subject to fail.

The method of depositing metal disks appears at present to be more convenient for use in schools although the punched card method yields more information.

In the instrument shown in the figure, in which the target is on fixed panels, presentation of the target, switching from eye to eye, insertion of the plus sphere, occlusion, operation of the code scoring lights, and the deposit of the disk are accomplished by logic circuitry, which depends heavily upon the newest forms of integrated components.

Recommended Screening Procedure

As a result of extensive field trials with this automated vision screener in schools in Massachusetts and elsewhere, recommendations have been formulated to promote an easy flow of children to and from the test area. These field trials have also improved the testing procedures and in particular have strengthened the important phases in which the children who are taking the test for the first time are given instructions. The most satisfactory procedure is to set up the test in an area such as the health room. A pool of approximately five children is kept in the test room at all times. As each child is screened, he returns to his home room, whereupon another child reports to the testing area. Use of an older girl student as an aide has proved satisfactory in testing in the higher grades. She passes out short, simple instructions to each child upon his arrival in the testing area and assigns him a numbered disk from a dispenser, which keeps the disks in numerical order. Keeping the disks in order facilitates identification of those children whose disks are found in the "Fail" compartment of the instrument. The aide also reminds the children about test procedures. Apart from this small amount of supervision, testing in the upper grades proceeds essentially unmonitored. In grades 4 through 12, grades in which the test is designed to be self-administered, false positives must be kept to a minimum. Therefore the giving of clear instructions and the use of psychological aids, such as shaped buttons for the Yes and No responses, are important.

The same procedure is followed in grades 1–3 except that the school nurse or other adult supervisor gives the test. All responses of the children at this level are verbal. The nurse always administers the retest, and a child must fail on this monitored retest before he is referred.

In field trials with the automated vision screener carried out in Massachusetts schools, considerably more than 5,000 children have been tested. School health authorities have been uniformly encouraging about the use of the screener. School nurses have been pleased with the requirement that monitored tests must be given to each child who fails a self-administered test before he is referred to an eye specialist. This requirement provides the personal involvement which many nurses feel is necessary in the development of sound follow-through procedures with parents.

The standards of the New England Ophthalmological Society, with slight modification, have been used for more than 30 years throughout New England and, in fact, in the most progressive school systems througout the nation. With these standards, a net failure rate of 9 percent may be expected in using the automated screener with school children. This rate applies in regions which historically have maintained comprehensive visual screening programs. Obviously, rates will be somewhat higher in regions in which fewer children have had corrections for visual errors. Moreover, very slight changes in ophthalmological standards will produce large fluctuations in failure rates.

Use of the automated screener with the standards provided by the New England Ophthalmological Society will result in negligible net

overreferral in terms of unfavorable reports from eye specialists to whom children are referred for care. The present overreferral rate for screening done in accordance with these standards is 3 percent, and experience up to now indicates that this percentage is approximately the overreferral rate that can be expected in using the procedures and standards recommended for the automatic screener.

Evaluation of Results

As a part of the field trials carried out over the past several years, the child growth and development section conducted a study of the correlation of the self-administered version of this new screening test with a free space version of the Massachusetts Vision Test first described by Sloane (*2*). This work was conducted in a manner similar to the investigation that Gentile and Johnston completed at the request of the New England Ophthalmological Society (*3*). With the methods for correlation used in the Children's Bureau study in St. Louis, the staff of the child growth and development section found that, in a sample of 187 children, the point correlation coefficient between the self-administered test and the standard free space version of the Massachusetts Vision Test was 0.77. This result is obviously well within the limits of correlation expected on the basis of established test reliabilities. It also represents a slightly better correlation than was obtained between the stereoscopic screener and the free space test version that Gentile and Johnston investigated for the New England Ophthalmological Society.

Additional studies have been carried out to determine the number of permissible errors that would promote the closest correlation of visual acuity measurements with those in the visual acuity sections of the free space version of the Massachusetts Vision Test. These trials have shown that the closest correlation with the free space version is achieved if one error per eye is allowed in the case of six presentations of E pairs or, alternatively, if two errors per eye are allowed in eight presentations of E pairs. Presentation of three pairs of plus sphere targets per eye with no errors permitted produced results identical with those obtained in the free space version when a line of six E's was presented with two errors permitted.

In using the automated instrument, provision is made for a skip of the second and third pairs of targets if the No button is depressed for the first pair in the sequence. This feature corresponds to the arrangement in the conventional plus sphere test in which no additional responses are demanded if the child reports blurring on the first target in a line of illiterate E's.

In a similar manner, automated sequences may be programed for tests other than the Massachusetts Vision Test. Since the optical characteristics of the automated device are conventional, only minor procedural changes are required to maximize the correlation with visual criteria established previously by other methods.

Summary

More than half of the working time of the staff of many school health departments is devoted to screening children for sensory impairments. An automatic screener can reduce the time spent in vision screening. With such a device, vision screening in schools and elsewhere can be done reliably, easily, and fairly inexpensively.

Integrated logic circuitry is now used extensively in the automated vision screener that Johnston designed and describes. The vision tests may be self-administered or administered by another person, such as the school nurse, in which case the subject responds verbally rather than by depressing buttons. In both modes, lens insertions, occlusions, and target selections are accomplished automatically. With the automatic screener, a wide variety of visual functions can be tested. These functions include visual acuity, latent hyperopia, heterophoria and color perception.

The targets may be presented on slides, on rotating film, or on fixed panels selectively illuminated. Lenses are inserted in the optical paths by the activation of rotary solenoids. Occlusion is effected by means of mechanical maskers or the selective extinction of illumination. Numbered metal disks or punched cards are used in scoring the self-administered tests.

Field studies indicate that test sequences may be programed so that they will produce results which will correlate closely with those

achieved with standard screening procedures, such as the free space version of the Massachusetts Vision Test. These studies also indicate that the net overreferral rate will not exceed 3 percent in those school districts which have previously maintained satisfactory vision screening programs.

REFERENCES

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(2) Sloane, A. E.: Massachusetts Vision Test. Arch Ophthalmol 24: 924–939, November 1940.

(3) Gentile, J. F., and Johnston, P. W.: A comparison of two school vision screening tests. Amer J Ophthalmol 52: 511–515, October 1961.

EQUIPMENT REFERENCE

(4) Tracor RA 116 Johnston vision screener. Tracor, Inc., Austin, Tex.

Chronic Alcoholism

Chronic alcoholism is not a defense to criminal prosecution for public intoxication. *Powell* v. *Texas*, 36 U.S.L.W. 4619 (U.S. June 17, 1968).

The Texas Penal Code provides that—

> Whoever shall get drunk or be found in a state of intoxication in any public place, or at any private house except his own, shall be fined not exceeding one hundred dollars.

Leroy Powell was arrested for appearing in public while intoxicated, found guilty, and fined $20. On appeal, the county court held a trial de novo at which the defense stated that Powell was "afflicted with the disease of chronic alcoholism . . . and that his appearance in public . . . was not of his own volition." The court found that the defendant was a chronic alcoholic with a compulsion to drink, but rejected this condition as a defense to the criminal charge and found him guilty.

A majority of the U.S. Supreme Court concurred in deciding that criminal punishment of a chronic alcoholic for public intoxication is not cruel and unusual punishment in violation of the eighth and 14th amendments to the U.S. Constitution.

The *Powell* case is somewhat unusual in that there is no majority opinion. Although Justice Marshall delivered the judgment of the Court, only three other members concurred, two of whom filed a special concurring opinion. Justice White reached the same judgment as Marshall, but did so on the basis of his own opinion. The remaining four Justices joined in a dissenting opinion delivered by Justice Fortas.

Justice Marshall devoted considerable attention to the current status of medical knowledge on alcoholism, concluding that "there is as yet no known generally effective method for treating the vast number of alcoholics in our society." Therefore, "Faced with this unpleasant reality, we are unable to assert that the use of the criminal process as a means of dealing with the public aspects of problem drinking can never be defended as rational."

While concurring in Marshall's opinion, Justice Black, who was joined by Justice Harlan, stressed the legal implications of a Court-

imposed "uniform" Federal rule of criminal responsibility. If it were accepted, as argued by the appellant, "that a person may not be punished if the condition essential to constitute the defined crime is part of the pattern of his disease and is occasioned by a compulsion symptomatic of the disease," it might be difficult to limit this extension of constitutionally sanctioned protection to the specific context of chronic alcoholism. Instead, it could by analogy be extended to all situations in which "compulsions symptomatic of a disease" led to criminal conduct.

Speaking only for himself, Justice White recognized the inappropriateness of criminal punishment of chronic alcoholics for public intoxication, but felt that under certain circumstances the alcoholic might be able to take "feasible precautions" against going to or remaining in a public place when drunk. The absence of evidence in the trial court record that these precautions were precluded to Powell apparently convinced Justice White that his conviction was justifiable.

The dissenting Justices felt that the case should be ruled by the principle set forth in *Robinson* v. *California* [370 U.S. 660 (1962)] that "criminal penalties may not be inflicted upon a person for being in a condition he is powerless to change." The dissent notes that the crime involved in *Powell* is "comprised of two elements—being intoxicated and being found in a public place while in that condition," which differs from the single-element "status" offense of being a narcotic addict with which Robinson was charged. Nevertheless, "the essential constitutional defect" is the same, "for in both cases the particular defendant was accused of being in a condition which he had no capacity to change or avoid."

Comment

It is ironic that Justice Marshall's opinion questioning whether alcoholism could be treated effectively was issued at approximately the same time that a committee of the House of Representatives reported out a bill (H.R. 15758, now in legislative conference) authorizing appropriation of several million dollars to construct and staff alcoholic treatment facilities. Moreover, the proposed legislation includes the following finding.

> The handling of chronic alcoholics within the system of criminal justice perpetuates and aggravates the broad problem of alcoholism whereas treating it as a health problem permits early detection and prevention of alcoholism and effective treatment and rehabilitation, relieves police and other law enforcement agencies of an inappropriate burden that impedes their important work, and better serves the interests of the public.

The effect that this type of legislative finding might have on a future case coming before the Court is conjectural, but such pronouncements have had noticeable impact on the judiciary in the past [see *Easter* v. *District of Columbia*, 361 F. 2d 50 (D.C. Cir. 1966)].

Justice Black states in *Powell* that he feels constrained to accept a State legislature's approach to alcoholism.

> From what I have been able to learn about the subject, it seems to me that the present use of criminal sanctions might possibly be unwise, but I am by no means convinced that any use of criminal sanctions would inevitably be unwise, or above all, that I am qualified in this area to know what is legislatively wise and what is legislatively unwise.

Thus, he would be inclined at present to accede to legislative "wisdom" in determining whether alcoholism should be subject to treatment as a disease or as a criminal offense.

State and Federal legislation, then, appears to be the best way to remove the chronic alcoholic from the street-court-jail cycle. However, since a vote of only four Justices is required to grant certiorari so that a case may be argued before the Court, and since such a strong dissent was filed in *Powell*, it is foreseeable that the Court might hear another, perhaps more fully developed and defined, presentation on the constitutional issue.—JOAN M. FULTON, *attorney*, and DAVID SAPADIN, *summer intern*, *Public Health Division, Office of the General Council, Department of Health, Education, and Welfare.*