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Computerizing orthoptics and visual therapy: Methods and applications

Abstract

In today's vision therapy environment, the practitioner has available the benefits and parameters of the computer age. The computerized vision therapy market is constantly changing, with many systems adding programs and capabilities; some new systems joining the market; and some systems falling by the way side. This thesis presents a review of the optometric literature dealing with the background and uses of computers in vision therapy, and other related areas of optometry. Specific computer - systems currently on the market, and designed totally with vision therapy in mind, are outlined and discussed. These systems are compared and contrasted; to include current costs; availability; and intrinsic capabilities. This review should answer some of the questions regarding what is available to the practitioner wishing to computerize his/her vision therapy procedures.

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William M. Ludlam

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**COMPUTERIZING ORTHOPTICS AND VISUAL THERAPY:
METHODS AND APPLICATIONS**

By

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A thesis submitted to the faculty of the
College of Optometry
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Advisor: William M. Ludlam, O.D.

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COMPUTERIZING ORTHOPTICS AND VISUAL THERAPY:

METHODS AND APPLICATIONS

GRADE A -

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Table of Contents

	<u>Page</u>
Abstract & key Words.....	1
Introduction.....	2
Review of the Literature.....	3
Review of Current Hardware/Software.....	10
Conclusion.....	20
Appendices:	
A - Computer Systems-table 1.....	24
Footnotes.....	25
References.....	26

Abstract

In today's vision therapy environment, the practitioner has available the benefits and parameters of the computer age. The computerized vision therapy market is constantly changing, with many systems adding programs and capabilities; some new systems joining the market; and some systems falling by the way side.

This thesis presents a review of the optometric literature dealing with the background and uses of computers in vision therapy, and other related areas of optometry. Specific computer systems currently on the market, and designed totally with vision therapy in mind, are outlined and discussed. These systems are compared and contrasted; to include current costs; availability; and intrinsic capabilities. This review should answer some of the questions regarding what is available to the practitioner wishing to computerize his/her vision therapy procedures.

Key Words: microcomputer, anaglyphs, strabismus, orthoptics, developmental, vision therapy, binocular vision, biofeedback, exotropia, amblyopia, accommodation, fixation disparity.

Introduction

Since microcomputers were first introduced in the mid-1970's, there has been an explosion of interest and application of them to all facets of everyday life. Recently, computers are being used in optometry as an effective aid in vision therapy. With the help of programmed lesson skills, baseline and progressive measurements can easily be taken of duction ranges, pursuits, saccades, phorias, motor fields, fixation disparities, suppressions, retinal correspondence, stereopsis, visual memory, and others. Only now, with the advent of computerized visual therapy, will it be readily possible to offer affordable access of these procedures to the general public and open new opportunities of optometry practice.

With the aid of the computer, a therapist can sustain patient interest and motivation while giving opportunity to train more than one patient during a session. Enhancement of skills using the computer can eliminate problems such as amblyopia, enlarge fusion ranges, break suppressions, increase oculomotor skills, treat strabismus, and improve accommodative facility. The skills can be measured monocularly or binocularly with a variety of first, second, or third degree fusional targets. The training can be programmed to be manual or automatic. Target speed, size, and frequency can be varied to a patient's specific starting abilities. Even the time of each exercise can be controlled. The results of the therapy for a session can then be printed out for a permanent legal record to be included in the patient's file.

The hardware supplied for each system usually contains a graphics compatible computer, color monitor, printer, keyboard with number pad, joystick, and anaglyphic spectacles. Software available for the systems currently marketed have up to 30 programs. There are complete packages, including all the hardware and software, available for under \$3200. The operating manuals are very descriptive of how each program can be applied, and a therapist can quickly be ready to use the full capacity of each systems potential.

This decade shows the beginning of an exciting era in vision therapy. The immense quantity of objective data collected from patients will make therapy undeniably successful. Patients will have the benefit of enhancing their vision. The training will be more uniform in manner; better correlation of test results between practitioners; and easier access to the number of practices able to support the therapy. This thesis will review the literature in optometry on the subject of computer use in vision therapy. We will also discuss specific computer systems on the market designed for vision therapy - including: costs, purchasing addresses, available software, and other features. Our intention is to reduce confusion and answer some of the questions regarding the role, availability, and capabilities of computerized vision therapy.

Review of the Literature

Computers are modern miracles which can assist us in almost everything we do. Microprocessors allow us to bring this technology into our homes. In the late 1970's and early 1980's

the 8-bit processors were used in microcomputers for the public. These were replaced by 16-bit chips in the early 1980's, which were faster and more versatile. Today there are 16-bit and 32-bit hybrids which enable the computers to access more RAM(random access memory); handle more complex commands; access multimega bytes of storage; as well as many more abilities.

It was estimated that by the year 1985, 75% of all jobs would involve computers.²² Computers and microcomputers have long since made their debut into the medical field. They are used in all aspects of managing the fast paced professions of health care; from storage of case records and other office managing functions, to measuring the proper power of intraocular lens implants. We now turn our sights specifically toward the role and applications of computers in the field of vision in a broad overview; and later we will narrow our discussion to computer uses in optometry, with our emphasis being placed on computer-aided vision therapy.

Computers play a major role in the diagnosing, testing, and treating of many ocular and visual problems. These techniques are available to all professionals in the eye care field. Both optometry and ophthalmology have been aided tremendously by computers and microcomputers in all aspects of vision care; from patient management and practice management activities,²⁶ to visual acuity testing;³ to diagnostic²⁴ and therapeutic applications.⁹

Much information has been published in the past seven years on the subject of biofeedback and its uses for treating eye-

visual disorders. Computerized apparatus have thus been applied to treating blepharospasms; training of voluntary torsions; strabismus;^{32,18} nystagmus; amblyopia/eccentric fixation; refractive error correction; and reduction of intraocular pressure/glaucoma therapy.³²

One device, described by Yolton³⁸ and Goldrich,¹³ is used in the treatment of strabismus. A photoelectro-oculography(PEOG) eye monitoring system is utilized. The apparatus is composed of infrared emitters and detectors before each eye, in combination with a sophisticated monitoring system. Both Yolton and Goldrich demonstrated that biofeedback is a useful treatment for many strabismus patients.

A computerized Three-Step Test is described in the literature by Raphael L. Vazquez, M.D..³⁶ A computer system utilizing a BCD(binary coded decimal) integrated computer circuit is used for diagnosing isolated cyclovertical muscle palsies. This computer method adds simplicity, speed, and reduction of the amount of anatomical knowledge needed to make a diagnosis for these muscle palsies, as compared to more traditional methods. The operation of the device described is very simple and the accuracy is limited only by the validity of the clinical data.

Duane's retraction syndrome is characterized by a marked limitation of abduction, restriction of adduction, retraction of the globe, and narrowing of the palpebral fissure on adduction. Howrie and Clement¹⁹ have used the computer to model the cooperation of the extra-ocular muscles to investigate the predicted effects of anomalous peripheral innervation. Their study demonstrated the features of Duane's syndrome, which can be

satisfactorily explained on the basis of misrouting of the normal innervation patterns.

From the Department of Psychology, York University, North York Ontario, Canada, a computer-based interactive apparatus for testing eye-hand coordination in strabismic and normal children³⁵ was developed and tested. The research was designed to discover the role that proprioception from the extraocular muscles plays in determining eye position. The researchers tested forty strabismic children using this apparatus. All were having strabismus surgery. Only pre-operative measures were available and published. Post-operative data could be obtained shortly after surgery though. Most of the children were willing to play the computer game even while recovering from the general anesthesia. Indications show the task to be intrinsically motivating; and this computer device is useful in various situations where eye-hand coordination in children is of interest.

Computers are also utilized in the assessment and evaluation of other binocular functions. The computer methods are shown to compare very well with traditional methods of measurement. An example of this is the work done in the area of fixation disparity by Yeager and Boltz.³⁷ In their study, Yeager and Boltz used the computer program called Digital Disparometer.

Digital Disparometer is written in BASIC and machine language for the Commodore personal computer. It is capable of measuring both horizontal and vertical(forced vergence) fixation disparity curves. The program is user friendly and flexible. It

is designed for clinical use, but may be adapted for research. Fixation disparity curves can be measured at virtually any distance with the device. It has been found to be useful in monitoring the efficacy and progress of binocular vision therapy, and in the prescription of prismatic corrections.

Yeager and Boltz compared the curves generated by the Digital Disparometer computer method, and that of the Bausch and Lomb phorometer; which is a traditional method. The subjects curves were found to be very similar between the two methods. Variations observed were no greater than what could be accounted for by accommodative influences and other inter-subject variations. The computer program appeared to be as reliable as conventional methods; but was quicker and made all the necessary drawings for the clinician.

Certain educational and commercially available programs may be modified by optometrists for the treatment of patients with perceptual problems, and developmental vision deficits. Maino²² has stated that most computer programs have not been specifically written for the pediatric optometrist, and we must search other professions to see what may be readily adaptable for our needs. He reported on Edu-Pak I, a series of programs on floppy disk released by Edu-Ware Services, Incorporated, in 1979. The selection was as follows: 1) Compu-Read, 2) Perception I (lengths), 3) Perception II (shapes), 4) Perception III (sizes), 5) Statistics.

There are many other commercially available software programs that could also be adapted for perceptual and developmental activities. For example, the Minnesota Educational

Computer Consortium(MECC) has released; Teacher Utilities - volume 1 (version 4.4), and volume 2 (version 3.1); and the Spinnaker Software Corporation has produced the program entitled Facemaker.²²

Now that we have reviewed the broad range of applications for computers and microcomputers in optometry and other disciplines in the vision care field, we can narrow our discussion to the area of computer aided visual therapy, methods and applications.

First, we will look at management applications. London, et. al.,²⁰ have designed a minimum data base and the resultant problem list for vision therapy. Their objective was to design a system that would improve the continuity and effectiveness of vision therapy, by reducing the confusion existing in standard treatment modalities, due to individual differences in data collecting among practitioners in general; and the technical and theoretical differences between teaching institutions and private vision therapy practitioners.

The problem oriented record format is comprised of five components: 1) specific data base, 2) problem plan list, 3) master problem list, 4) progress notes, and 5) a flow chart. This record format provides a stringent recording system and provides practitioners and students with a logical approach to patient care; and encourages learning even when confronted with difficult cases and unfamiliar therapeutic methods and programs. These authors know that always making the proper therapeutic choices cannot be guaranteed with their system; but it does offer

an excellent method for identifying and monitoring the needs of vision therapy patients.

Articles identifying the clinical benefits of video did not appear in the optometric literature until 1981. It was found by Fujimoto, et. al. in 1983¹¹ that the use of videocassette techniques for saccadic therapy to be as effective as traditional methods. This initial video training was a precursor to more computerized types of vision training. Computer training can now be applied to the following activities and more:^{9,14,15,21,23,28.} tracking, saccadic fixations, ductions/vergences, anti-suppression, retinal rivalry, fusion, stereopsis, strabismus training, random dot stereograms, jump ductions, amblyopia training, tachistoscopic skills, phorias, perceptual training, motor field, visual acuity, fixation disparity, accommodative facility, Hess-Lancaster motor fields, stereoacuity measurements, and objective and subjective angle determination in anomalous retinal correspondence.

In 1982, Cooper and Citron,⁹ evaluated microprocessors for use in vision therapy techniques, which were currently on the market at that time; the Apple II, Atari 800, Commodore(PET), and the color Radio Shack(TRS-80). The Apple II was found to have poor color production and only one luminosity level. The PET produced only black and white graphics; lacked expansion capabilities; and inadequate memory. In 1982, it was the opinion of these researchers that the Atari 800 system was the best choice for testing, training, and studying binocular vision anomalies. It had the ability to produce sophisticated red-blue graphics, which were used anaglyphically; adequate memory; and

functions to expand its capabilities.

In 1986, Gosnell¹⁴ reviewed the available hardware and software that would be suitable for vision therapy. The systems he looked at were as follows: The Atari 1040ST, the Commodore Amiga, Commodore 64, Commodore 128, Atari 130XE and the Apple IIc. Gosnell's choice was the Commodore 128 for the following reasons: 1) reasonable price, 2) adequate amount of RAM, 3) expanded BASIC with graphics, 4) large selection of software available, 5) recently introduced model (not likely to be discontinued soon.)

Review of Current Hardware/Software Systems

The following paragraphs will cover five computer visual training systems we found available for optometrists to use in their offices. The computerized vision therapy market is very volatile, with many systems coming and going as new ideas are tested. It is not the object of this hardware/software market presentation to be critical or supportive to any one system; but to describe the system for the positive advantages which are available to the therapist. Neither do we attempt to cover every software/hardware option available; since they are constantly in a state of flux. The following systems were chosen to include a variety of inventors; from the earliest to the latest; from the most expensive to the least expensive; from the most developed to the simplest design application. Subjective conclusions about how well any system will work is left up to the individual to decide for their particular clinical needs. All of the following

systems have something to offer vision therapists; with a wide variation on cost, depending on the elaborateness of the system. Enclosed at the end of the discussion is a condensed table of various options available with each system for easy reference.

Copycat

Copycat is a computerized geoboard at its simplest level of operation. It utilizes the Rosner Test for analyzing visual skills and all 200 of his patterns are in the program. It is very easy for the therapist to use and adapt. The hardware requirements call for a Commodore 64 or 128, monitor, printer, 1541 disc drive, and a Koala light pen.^a The cost of this hardware is very reasonable and equipment support accessible. The current software price is \$384 and includes the light pen(warranty for 2 years), floppy disc, and descriptive manual.

The program starts by entering the patient information and electing of the different patterns to use for the session. One also selects whether the pattern will appear on the left or right side of the screen. The #1 pattern is the easiest, up to #190, which is very hard. The patterns can be displayed all the time while a patient copies with the light pen onto the other side of the screen; or flashed for tachistoscopic visual memory work at whichever time interval chosen. Patients can increase the difficulty by being asked to flip the drawing right to left; top to bottom; or rotated 180 degrees.

The computer records the date; beginning pattern; time it took for the session; display options chosen; number of patterns finished; and the percentage of correct patterns completed.^a

This information is stored on the patient's disc, or can be printed anytime for a hard copy record.

Putting red-green filters over the computer screen and wearing red-green spectacles allows patients to do anaglyphic procedures using prisms and lens flippers. The following therapy exercises can be performed: accommodation rock or amplitude, fusion ranges, cheirosopic tracing, monocular, or monocular in a binocular field.

Dr. Peed's experience with his Copycat programmed device, and the other doctors he has sold the program, find it a valuable tool and motivator for therapy patients. It is a very inexpensive system that any doctor/therapist can initiate in his/her office; and provide the advantages of computer supported therapy. Copycat has much to offer.

Beyond Vision, Inc.

Beyond Vision Inc. offers two programs for the doctor providing visual therapy; Computerized Developmental Vision and Computer Assisted Orthoptics. Each of the above software packages are sold for \$2400 and include instruction videotapes, workbooks, patient forms, and other necessary tools applied to the therapy. Susan Foster, their director of sales, says there are over a hundred optometry offices using their system currently.

Computer Assisted Orthoptics(CAO) operates on any IBM-XT compatible system and many offices have been choosing Compaq hardware very successfully. BVI will sell hardware compatible

for their system, but encourages practitioners to find a local computer dealer which can provide closer service options. Their software/hardware package price varies by the equipment chosen for the custom package; and all parts have a 90 day warranty - service contracts are available._b

The CAO program allows the therapist to choose variables of distance, target size, speed, and form of target. The RGB color monitor allows for sharp red/blue image separation, without shadows. Duction, accommodation and tachistoscopic training are available; along with tests for phoria/disparity, stereoptic, saccadic, and accommodative work. Each training and testing routine allows for different variables to be customized to patient needs.

The American Institute of Research_q studied the effectiveness of the CAO system. Their results found no significant improvement difference on slow readers trained by the computer, over traditional methods. It was a good study and there are many more questions to be answered in this area for all computer vision therapy programs.

The Computerized Developmental Vision(CDV) program is divided into 3 batteries: screening, diagnosis, and therapy. The primary use of the computer is for entering patient data manually, which then computes a diagnostic score. The major training emphasis is by videotaped instructions. The results of the screening battery can be printed out for explanation to patients, parents, or teachers. If the patient fails the screening, it is because they have a binocular vision difficulty. All binocular vision difficulties are recommended to be

alleviated before going on with the developmental series. In the diagnosis phase, tests are given on eye movements, visual processing, visual integration, auditory processing and mental maturity. Entering the test results manually into the computer enables a performance score to be internally tallied; then normed to the particular age of the child. Depending on a patient's performance, a therapy program design is recommended in workbook format to take home. The patient's weekly performance is entered into the computer for storage of accurate records.

The back-up support from this company is well organized and their initial supply of forms usually lasts the average practice six months. Replacement packet forms are relatively inexpensive and easily accessible on their 800 telephone line. Many optometrists are successfully using this system across the country and references are available upon request.

Susan Foster finds some offices have both programs, but says, "doctors on the east coast have been preferring orthoptics; west coast have been buying developmental; and the midwest has been mixed." She feels this reflects what has been emphasized to the practitioners from the schools in those areas. Beyond Vision is a system design to consider for the doctor/therapist looking for further options to train their patients in orthoptics or developmental sequences.

The Opti-Mum System™

The Opti-Mum series I has 30 programs, covering 6 areas, to treat vision therapy patients: 1) diagnostics, 2) basic learning skills, 3) intermediate learning skills, 4) binocular visual training, 5) amblyopia therapy, and 6) strabismus training. The Amiga computer, by Commodore, is used to provide high speed excellent graphic capabilities with good color regulation. The Amiga is a very powerful system and inexpensive service is available nationwide, as for all Commodore products. The software, without the Amiga hardware, is only \$1595; the Amiga 2000, including software, is \$3195; and the Amiga 500, with software, is \$2595. The Amiga 2000 can be made fully IBM compatible with a \$500.00 XT bridge card, for practitioners seeking this option. The programs have speech synthesis, and the computer voice talks to the patients about their good efforts. Children really enjoy this positive vocal feedback in their close relationship with the computer in vision therapy.

There are a variety of menus used to adjust the difficulty of each program to suit the individual needs of the patient. The flexibility of the parameter design in the programs, allows for successful therapy interaction; ranging from difficult strabismics, to highly binocular athletes, wanting to enhance their performance.

An example of the flexibility built into the 30 programs can be demonstrated in the saccadic menu: type of path to choose, length of the path, symbol choice, symbol size, symbol separation, display time symbol is on, time interval symbol is

off, and the length of the session for that particular area. The optometrist can thus customize the training program to the patient's ability level.

The manual is designed so operators from a wide range of backgrounds can understand the training design goals. It addresses theory; parameter changes and effects; interaction between computer, patient and therapist; hierarchy of training to achieve best results; and the goals of each training program is design.³⁵

The computer is designed to achieve success not easily attainable by the traditional mechanical or optical manipulations. One of these is time-sequenced reproduction of information, which is the skill necessary for spelling in written language. "We have found that in presenting words letter-by-letter in a time sequenced progression, the written material is being input through the visual system in a mode similar to (but reversed from) the output required when spelling."³⁵

The other valuable solution, with this computer design, is eliminating the crowding phenomenon found commonly with strabismics having amblyopia. The acuity is taken by identifying one particular target of choice to find the patient's threshold. At this point the target size can be either reduced, or other target distractors of the same size introduced at their ability level. "Attacking contour interaction progressively with this much flexibility quickly shows patient improvement back to the whole line acuity chart. This is very hard to do with any other instrumentation modality."³⁵ The computer records qualitative and quantitative progress automatically in the file. Currently,

homework discs are being developed for patient's to use on their own computers. The homework software will be compatible with Apple IIe, and the Commodore 64/128 systems for release by August, 1988.

Learning Frontiers offer, The Opti-Mum System,TM developed by William Ludlam, O.D. and Diana P. Ludlam, O.V.T.. Dr. Ludlam is also the author for the strabismus and amblyopia chapters in Borish's, Clinical Refraction. He brings to the system a critical understanding of the results optometrists want to cure their patients. Over thirty systems are operating in offices nationwide, since just being developed for sale. Continuing updates of their software improvements are offered free; and phone support is always available for any design questions or suggestions. This system is well liked and should satisfy the professional needs of vision therapy instrumentation into the future.

Indiana University

Merrill J. Allen, O.D., Ph.D.

Indiana University School of Optometry has developed programs to use in their vision therapy clinic over the past four years. It utilizes the Commodore 64 or 128, with 1541 disk drive, and 1702 color monitor. The equipment is inexpensive and can be serviced anywhere very easily. The system is popular with the patients and homework assignments are being programed onto discs to continue training throughout the week. Since the homework requires use of a home computer, the clinic has offered

to buy the hardware back for half price after training is completed. Once used to their computers, no one has offered to sell them back over the last two years.c

The computer stores the patient's training results and allows the doctor to know their exact progress. "Auditory biofeedback is used along with the visual stimulus to motivate patients to the targets."²⁵ The binocular problems addressed are: simple exophoria, convergence insufficiency, measuring visual acuity, visual-motor reaction time, amblyopia(without contour interaction capabilities), contrast sensitivity, acuity and light scatter(cataract), tachistoscopic and speed reading, saccadic fixation training, and accommodative rock.c

Dr. Allen is currently working on a computer program which will do accommodative rock with cross cylinder targets. The patient wears cross cylinder lenses and the computer changes the orientation of the targets to match the accommodative demand of the cylinder in the same power meridian. This rocks the accommodation without the need of other lenses; and frequency can be controlled by the computer program variables. Further testing may be necessary before this also becomes available in the near future.c

The existing software and manual is available for sale at \$150. Over a half dozen vision therapists are using the program, other than at the university, and are available as references. This year is the first time this package has been offered commercially to doctors/therapists, and Dr. Allen looks forward to practitioner's success. He can be contacted directly, and welcomes feedback and further ideas on improving all of the

vision therapy programs for the best training results.

Computer Orthoptics

Computer Orthoptics was developed by Jeffrey Cooper, O.D. The cost is \$3185, plus \$65 for shipping; and includes hardware of Atari 800, NEC high resolution RGB monitor, joystick, touch tablet, color printer, anaglyph glasses and manual. The software included has 27 diagnostic and therapeutic programs in two separate cartridges; one diagnostic and one therapeutic.⁹

The diagnostic testing programs include measurement of vertical and horizontal phoria, stereopsis, accommodative facility, fusion ranges, Worth 4-dot, objective and subjective angle and angle of anomaly, motor fields(Hess-Lancaster), saccades, visual memory(tachistoscopic), and accommodative rock. Leonard Press, O.D., has this complete system and says, "My experience has been that the diagnostic program is of relatively little practical value as compared with conventional tests of similar functions."²⁴

The therapeutic programs are recommended by Dr. Press and include jump ductions, pursuits, saccades, visual memory and accommodative rock. The performance is automatically recorded on the disc and can be printed for a hard copy file to follow the patient's progress. Some of the variables available are monocular, binocular, manual operation, automatic, speed, target size, time of program length, and static or kinetic movements. This system can be used for testing, training and studying binocular vision and anomalies of binocular vision.¹

The programs are very flexible to meet the needs of patients, though the perceptual and developmental areas are currently lacking. Programs are now being designed to cover these areas by Sidney Groffman, O.D., and should be available by the summer of 1988. Further development projected for fall of 1988 will cover an infant vision program; and new computer orthoptic procedures, with greater emphasis on strabismus and amblyopia.¶

The Computer Orthoptics system is popular and found in over 100 vision therapy offices across the country. Dr. Press also says, "In early 1985, it seemed that Computer Orthoptics was the most complete and integrated system available in the realm of computerized vision therapy."²⁴ Leasing terms are available and possible discounts to new graduates for up to one year. Mr. Rod Bortel markets the system and says, "We are committed to vision therapy and there is an unconditional guarantee for 3 months after purchase for a full refund and no cost pick-up/return."¶ Dr. Cooper's system has provided a good platform on how to dedicate the computer to vision therapy. Doctors using the system in each state are available for consultation and a list will be provided by the company. The continuing development of vision therapy software tools from Computer Orthoptics will be very beneficial to doctors for treating their patients in the future.

Conclusion

The five systems discussed give some of the common parameters to look for in a good system. Computer Orthoptics and

The Opti-MumTM Systems are the major designers/suppliers in the current field of development; along with Beyond Vision's videotaped developmental vision and computer assisted orthoptics(100 systems in use).

Many other doctors are pioneering programs to help their patients sustain interest in vision therapy sessions. These other systems offer a creative source for more good ideas to be launched into this growing field. Indiana University's program and Copycat have great potential with a moderate price. The Commodore and Amiga series computers offer powerful options to communicate with other doctors in this area. The benefits are now obvious to practitioners and patients on this new medium for treating binocular anomalies and enhancing developmental therapy.

We have looked at the role of computers in vision therapy and how they are used. There is little research cited in the optometric literature as to the efficacy of computerized vision therapy methods as compared to traditional methods. Major and Piroette²² performed a comparative study which investigated the effectiveness of computer-assisted duction training, versus standard(traditional) duction training. The subjects in the standard training group used the Wheatstone Mirror Stereoscope, Polachrome Orthopter, and the Aperture-Rule-Trainer(both single and double apertures) in sequence. Subjects in the computer group used a Commodore 64 computer, color VDT, joy stick, and 10 diopter base-up OD, and base-down OS prism spectacles. The training time for this group was divided among three different targets of increasing difficulty. It was found in all cases the

computer group results exceeded those of the standard group, but not significantly. This study implies the value and usefulness of computerized vision therapy techniques; and also lays the foundation for further systematic study and research.

The doctors/therapists which seek more information on the topic of computer use in vision therapy can use this paper's bibliography as a source of further literature. A computerized search of all the literature was done to find every possible article written in this area; and we have researched the various journals up to March/1988. Currently, Dr. Leonard Press is coordinating the authorship of articles published in the Optometric Extension Program's newsletter and titled, "Computers and Vision Therapy Programs." He started profiling various therapy systems since October, 1987 and will continue through the spring of 1988. The reader interested in this market will find these articles informative and up-to-date beyond the timetable of this literature search; and they are highly recommended for OEP members or non-members.

This decade shows the beginning of an exciting era in vision therapy. The immense quantity of objective data collected from patients will prove therapy undeniably successful. Patients will have the benefit of enhancing their vision and eliminating general binocular dysfunctions which will allow them to achieve their full visual potential. It will be a tremendous advantage to the students and workers of tomorrow who need to use their eyes efficiently to learn. The training will be more uniform and the results more correlatable between doctors; and there will be easier access to the number of practices able to support the

therapy. The pioneer optometrists who developed visual training success through the mechanical age are becoming the future programmers for therapy into the next century. The next twenty years of developing progress in this area will serve patients well and open exciting avenues of optometric practice.

TABLE 1

	A	B	C	D	E	F	G	H	I
1	Company Name/Address	System Name	Cost Software	Cost Software/Hdwre	Training	800 Number	Support	# Oper. Systems	Refrnces avail.
2									
3	David Peed, O.D.	Copycat	\$384	Independant	Manual	404-576-5500	Unlimited	6	Yes
4	5887 Hamilton Road								
5	Columbus, GA 31909								
6									
7	Beyond Vision, Inc.	Computerized	\$2,400	Variable furnished \$	Manual	800-252-3015	Unlimited	50	Yes
8	Two Market Square Center	Developmental		or independant					
9	251 East Ohio Street	Vision							
10	Suite 525								
11	Indianapolis, IN 46204	Computer	\$2,400	Variable furnished \$	Manual	800-252-3015	Unlimited	50	Yes
12		Assisted		or independant					
13		Orthoptics							
14									
15	R. C. Instruments, Inc.	Computer	N/A	\$3,185	Manual	800-346-4925	Unlimited	100	Yes
16	99 West Jackson Street	Orthoptics							
17	P. O. Box 109								
18	Cicero, IN 46034								
19									
20	Indiana University	V. T. Lab Disc	\$150	Independant	Manual	812-335-8629	Unlimited	6	Yes
21	Merrill Allen, O.D., Ph.D.								
22	800 East Atwater								
23	Bloomington, IN 47405								
24									
25	Learning Frontiers, Inc.	Opti-Mum							
26	2444 Solomons Is. Rd.	Amega 2000	\$1,595	\$3,195	Manual	800-331-6412	Unlimited	30	Yes
27	Suite 205								
28	Annapolis, MD 21401	Amega 500	\$1,595	\$2,595	Manual	800-331-6412	Unlimited	5	Yes

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