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Automation in optometry (the implications and impact) and the use of computers in optometry

Steven M. Hines
Pacific University

Monte A. Gallinger
Pacific University

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Abstract
Automation in optometry (the implications and impact) and the use of computers in optometry

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by

Steven M. Hines
Monte A. Gallinger
Advisor - Lynn J. Coon, O.D.

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TABLE OF CONTENTS

Never in the history of man has the world advanced so rapidly. Fifty years ago, todays world would have been science-fiction. Yet, through "science-fact" we live in a nation which is nuclear powered, computerized, space exploring and disease conquering.

However, these advances are also accompanied by modern problems. We face inflation, population explosion, nuclear proliferation, and environmental/resource degradation.

The topic of automation in optometry may seem out of place in this context. Yet, it is inevitable that scientific and social revolutions will have profound effects on optometry.

No profession can reep the benefits of today's society without first facing its changing problems and attitudes. Also, we should expect change to continue even more rapidly than today.

Some view automation as a radical change which will destroy many components of the profession and doctor-patient relationships.

Others view automation in optometry as simply advancing instrumentation and diagnostic scope and potentials of the profession for the good of all.

In order to do justice to the topic of automation and its impact on optometry, we shall first provide a show-room-model illustrating the potential changes of automation.

Then we shall analyze the assumptions and implications of each aspect of the futurized model.

Finally, conclusions will be drawn, after an understanding of all the parts are grasped and the model can be reassembled to see if it can pass the "road-test" each individual optometrist has personally conceived before welcoming or fearing its arrival.

Those who do nothing about the future must accept it without complaint. A thesis of this nature will at *least* provide a comprehensive look at some future crossroads in technology and possibly spur a few imaginative minds into actions which will allow these problems to be answered in a manner which sustains optometric professionalism while continuing to provide maximum quality vision services.

This paper will attempt to put into an optometric perspective areas such as:

AUTOMATION: AN HISTORICAL PERSPECTIVE
THE IMPACT OF AUTOMATION: A MODEL
AUTOMATION: IS IT NECESSARY?
THE CONNECTION BETWEEN AUTOMATION AND HEALTH LEGISLATION
THE TECHNICIANS ROLE IN AUTOMATED OPTOMETRY
PATIENT RESPONSE AND ACCEPTANCE
AUTOMATION AND THE INDIVUDUAL OPTOMETRIST
FUTURE ROLE AND SCOPE OF OPTOMETRY
INTERPROFESSIONAL RELATIONS
COST: MONETARY
COST: PROFESSIONAL (WILL AUTOMATION BE ACCEPTED)

AUTOMATION: AN HISTORICAL PERSPECTIVE

A mere forty years ago the word automation did not even appear in the dictionary. Today, it is defined as: "the technique of making an industrial process or system operate automatically; by extension, the use of electronic or other mechanical devices to replace human labor," (Oxford-English Dictionary: p. 159, 1972).

Predictions of advances in science and technology generally have been notable for inaccuracy. As an aid to estimating the impact of automation on optometry one must reflect on the milestones which brought the profession to its present state:

Reading glass (Roger Bacon, 1266)
Spectacles (in Venice, 1270)
Prisms (Kepler, 1604)
Refractor (Zahn, 1685)
Bifocal (Benjamin Franklin, 1775)
Cylindrical lenses (Airy, 1827)
Crossed cylinder (Stokes, 1849) [1]

As one can see the technological advances in optics into the nineteenth century were mainly in theoretical and physical optics.

From that foundation came the building blocks which structured the birth of optometry:

Retinoscopy (Bowman, 1859)
Opthalmoscopy (Helmholtz, 1851)
Slit-lamp microscopy (Gullstrand, 1911)
Tonometry and visual fields
Corneal contact lens (Touhy, 1949)

The following advances may dismay those who believe that optometry should not change its role or who believe that the evolution of the profession has provided a static and unchanging niche of security:

Hydrogel contact lens (Wichterle, 1960)
Visual neural development (Hubel-Wiesel, 1963)
Automated retinoscope
Automated perimeter (Octopus)
Guyton astigmatic optometer (refractor)
(1970's) Humphrey refractor
Computer refractor
Visual evoked potential examination [3]

The advances in instrumentation directly usable in the visual sciences goes far beyond this short list. In the past thirty years alone, technology has created potentials which dwarf the genius of the previous seven hundred years.

Advances in visual tehcnology aided the optometrist to develop the scope of today's modern practice. Improved instrumentation made eye-disease examination and diagnosis and massive public use of contact lenses possible.

The list of instruments alone can *potentially* become the forerunners of a sophisticated system of automated instrumentation allowing improved usage of materials, prevention of visual-neural anomalies, improved diagnosis of disease, and even physiological modification of refractive states. (See Table 1)

TABLE I

MILESTONES IN THE SCIENCE AND TECHNOLOGY OF VISION & OPTOMETRY

Year A.D. (Non-Linear Scale)	Scientific Concept	Technological Advances
<1300	Catoptrics	Mirrors
		Spherical lenses
		Reading glass (Roger Bacon, 1266)
1300		Spectacles (in Venice, 1270)
1600	Myopia, dioptrics (Johannes Kepler, 1604)	Prisms (Kepler, 1604)
	Refraction in the eye (Christopher Scheiner, 1619)	
	Optical correction for myopia & aphakia (Daza de Valdes, 1623)	
	Law of Refraction (Willebrord Snell, 1637)	
	Anisometropia (Johann Zahn, 1685)	Refractor (Zahn, 1685)
	Hyperopia (Isaac Newton, c. 1700)	
		Biofocal (Benjamin Franklin, 1775)
1800	Astigmatism & optical constants of eye. Accommodation in lens. (Thomas Young, 1801)	Cylindrical lenses (Airy, 1827)
	Binocular vision, stereopsis (Wheatstone, 1838; Donders, 1864	Crossed cylinder (Gabriel Stokes, 1849)
	Compound optical system (Gauss, c. 1841)	
	Dioptrics of eye (Helmholts, 1856)	Retinoscopy (Bowman, 1859)

(continued next page)

TABLE I (continued)

Year A.D. (Non-Linear Scale)	Scientific Concept	Technological Advances
1900	Eye disease examination	Opthalmoscopy (Helmholtz, 1851) Slit-lamp microscopy (Gullstrand, 1911) Tonometry Visual fields
1950	Contact lenses	Corneal contact lens (Touhy, 1949) Hydrogel contact lens (Wichterle, 1960)
1960	Visual neural development (Hubel& Wiesel, 1963)	
1970	New instruments for eye examinations	Automated retinoscopes Automated perimeter (Octopus) Guyton astigmatic optometer (refractor) Humphrey refractor Computer refractor Visual evoked potential examination

Past ⟶

THE IMPACT OF AUTOMATION: A MODEL

The office of the future may bear little relationship to the practice of today.

Modern technological change will provide instrumentation for evaluation of visual fields by computer; computer-controlled refractive systems; utilization of lasers in examination techniques; visually evoked cortical potentials; infrared optometers; automatic retinoscopes; static and dynamic visual acuities by computer; ultrasonic instrumentation; electronic data processing; as well as fabrication of eyewear within minutes controlled by a mini-computer system. Central computer banks will eliminate filing cabinets, provide health-history files, and automatically do billing. New instruments will perform electoretinograms (ERG) and retinal photography and electronically compare them with thousands stored in memory banks, providing the optometrist with a percentage diagnosis of possible abnormalities.

This list is not complete, every aspect of visual care can be influenced to some degree by modern technology.

Computers will be utilized to take the patient's history, including that available in the central computer banks.

It will be unnecessary for the doctor to be concerned with financial arrangements. The amount due will be transferred personally or through insurance identification from the patient's account to the doctor's office account by computer.

"The total patient time in the office could involve approximately one to one and one-half hours. However, the important thing is that the doctor would not be required to spend more than approximately fifteen minutes with each patient. He would then review test data and histories taken by paraoptometric technicians, review internal fundus evaluations, arrive at a final diagnosis and prescribe for the patients visual needs." He would consult with the patient concerning unique problems and necessary speciality needs, to be referred to a specialist.

"In this manner approximately 30-35 patients per day would be seen by the doctor allowing him one hour per day to dictate reports, letters and miscellaneous items requiring his attention." [4]

A much more feared model is the following: Mrs. Smith needs a pair of glasses, so she heads for her favorite department store. Her examination consists of looking into an instrument and turning a knob as directed. The instrument cranks out her new perscription. She selects a frame from a catalogue and punches her choice into another instrument along with her checking account number. Ten minutes later she goes to a window and an attendant fits her new glasses.

Any profession would shutter at the possibility of such an erosion of the doctor/patient relationship. Visual perception is a very subjective process, requiring more than technicians who rely wholly on computer results, without checking them further.

To many optometrists the use of automated instruments may lead to abuse as reflected above.

Whether the first model or the second or something in between finally occurs, depends on how optometry views its future scope and role as an integral part of the visual-health-care delivery system and how forces external to optometry force change.

This paper will not elaborate on the technical aspects of automation. Article upon article could be quoted as to the worth of future instruments as opposed to present technology and subjective optometric precision.

As more large companies enter the production field, costs will inevitably be driven downward; further research will yield higher accuracy and reliability levels in devices. This will begin to change attitudes and opinions leading to more and more utilization.

Most experts agree that the precision and limits of future instrumentation will exceed the subjective accuracy and speed of its human counterpart. It's just a matter of time! The technical and engineering precision of present day automated instrumentation is a mere forerunner of technically superior instruments.

As the retinoscope of 1859 was vastly improved to its sleek present-day model, the instruments of tomorrow will continue to be improved.

The assumed issue raised by automation in optometry is not technical in nature, but *human*!

Automation may become a catalyst to a revolution in optometry, provided important questions are satisfactorily answered. How will it change the scope and role of the profession? Can the solo-general practice survive? What will be the role of the paraoptometric technician? Can demand for optometric services off-set costs? Will the quality of service decline? What will be the role of government in health-services regulation? All of these questions comprise the hidden parts of the above model. For it to work smoothly and be welcomed instead of feared, these questions must be addressed.

IS AUTOMATION NECESSARY?

Can optometry meet the demands of full-vision care for every citizen seeking care, without changing at all?

The answer comes down to effective and sufficient optometric manpower.

Different methods of establishing "need" for vision service have produced different ratios of optometrists to patients. Presently, the AOA accepts 1:7000 as the *preferred* ratio.

Today it would require 7200 more optometrists to reach this ratio. Between 1950 and 1970, the ratio went from 14 to 10 optometrists per 100,000 persons.

Current output from colleges of optometry is insufficient to compensate for rates of attrition. To keep pace with attrition and population increases 850 new optometrists are needed yearly. From 1954-1970 only an average of 387 were graduated, a shortfall of better than 50%. [5] This figure did not include the impact of part-time professionals or enactment of national health insurance.

Manpower needs are influenced by changes in productivity, the use of paraprofessionals, increases in the demand and use of services as a result of awareness by the public, third party involvement, and changes in the scope of practice. [6]

Health insurance, group contracts and prepayment plans are conservatively estimated to raise demand for services by at least ten percent. [7]

The age distribution of optometrists is of particular interest because of its implications for the future supply of optometric manpower in the United States. Seventy-five percent of the active optometrists are over forty and fifty percent over fifty years of age. [8]

"Around 1980 we can expect a rash of retirements as those who entered the profession after World War II leave the profession. All of these factors result in a needed projection increase of as much as 200% in optometric manpower production." [9]

Another grim aspect of facing a large increase in demand is the disturbing fact that fewer students are applying to schools of optometry.

The student applicant pool has declined by 10 percent (400), for September 1978, down from 4000 to 3600 in one year. We do not stand alone with this problem, for medical and dental applicants have fallen off 10 to 20 percent also.

The reasons for decline are many, but the critical issue is the need to prevent any further reduction. The student applicant pool, its size, social characteristics, and academic and intellectual composition are of fundamental importance to every optometrist concerned with the future course of our profession and its public responsibilities. [10]

To meet the 1:7000 figure the profession would have to double in ten years, provided the population growth reaches the estimated figures of the bureau of census. [11]

At face value, the above figures provoke concern; however, the projections are arbitrary. Analyzing manpower needs with the 1:7000 ratio may be misleading. The statements may not reflect demand. *Need* is defined as the amount of care believed necessary, while *demand* is the actual use of vision services.

Some conclusions can be drawn. First, manpower production should not drop lower than today. Second, the passage of national health insurance incorporating the full scope of optometry would surely have a great impact on manpower needs. Finally, the increase necessary is beyond the capabilities of professional schools at this time.

Fortunately, the answer to the problem is not dependent upon graduating vast numbers of optometrists. Efficient utilization of professionals, para-professionals, and technological advances in instrumentation could increase productivity to match potential demand.

The foregoing discussion implicates two further areas of concern, national health insurance and the use of ancillary personnel.

THE CONNECTION BETWEEN AUTOMATION AND NATIONAL HEALTH INSURANCE

Health care is taking an even larger percentage of the gross national product (at present 7.8%) and the technological imperative in medical care will make it even more costly. [12]

In most industries new technology has increased productivity and cost control. In health care; however, technological advances have improved diagnostic procedures but added to the cost of delivery.

The impact of health care on the public will continue to invite public scrutiny and government regulation.

It is no longer the politically powerless poor who suffer inadequate medical care. The American middle class - because of the inefficiency of the system, lack of protection from catastrophic illness and steeply rising costs - is now adversely affected. [13]

The number of health care bills introduced at all levels of government have increased rapidly, and a national bill is increasingly possible.

National health insurance will come, but not immediately in a truly comprehensive form. "By 1985, we will have evolved a much broader, more universal type of national health insurance than initially enacted. We will have experimented with other plans and will find that they will fall short and tend to divide the population into groups with varying coverage. We will then turn toward the more comprehensive universal type of coverage that is envisioned in the Health Security Act, the Kennedy-Griffiths legislation." [14]

THE TECHNICIANS ROLE IN AUTOMATED OPTOMETRY

If the costs of automation are to be overcome within government and public expectations, increased productivity will demand skillful usage of paraoptometric personnel.

It is interesting that in the context of this discussion the words "technician" and "paraprofessional" are synonymous with "automated instrumentation". Both effectively remove the optometrist from the one-to-one role of present day doctor-patient relations. Both are needed in an automated office and both are needed for effective cost control and efficiency.

Substituting less expensive input (paraprofessionals) for more expensive (optometrists) may result in increased productivity and/or lower costs. [15]

The evolution has already begun and a few examples of *present day* use of technicians and automated instrumentation are now provided.

The first example is that of Ben Parrish, O.D. In his article he examines the question of improved efficiency, high quality performance and favorable patient response using technicians and the Humphrey Vision Analyzer automated refractor.

The author considered improved efficiency to be primarily the reduction of the refraction time by fifteen to twenty minutes, accompanied by efficient use of technicians, making it possible to see 25 patients per day.

He considered the system to be of high quality due to less ambiguous subjective tasks, no lenses or apertures in front of patient, being binocular with no dissociation, controlling vertex and allowing quick overrefraction.

Finally, the question of patient response was favorable. He felt patients were impressed with the appearance of such an instrument, seemed more confident with their responses, and still interacted with the doctor during the "computer assisted" evaluation.

The author's methods are illustrated on Table 2 and 3.

At the bottom line this author felt the original investment had increased his income and patient load. [16]

On the other hand, this approach already worries some O.D.'s. Many see the very same set up as impersonal patient care, use of unskilled technicians and the rise of mass refraction by unscrupulous eye doctors.

A recent poll of the National Panel of Doctors of Optometry included these remarks:

> "Automated refraction ignores the human element".
>
> "The patient feels rushed; he feels the doctor doesn't care because he turns him over to an assistant who doesn't care either".
>
> "The patient thinks the O.D. wants his money quickly, so he can get rid of him".
>
> "Automated refraction will be misused by those who are unskilled at basic manual refraction. Soon department stores will have do-it-yourself exams".
>
> "But I'm afraid of the quickie exam, where there is no case analysis of a patient's needs. The refractor could be costly window-dressing".
>
> "They are very expensive retinoscopes". [17]
>
> Will non-technical personnel arrive at a "manufactured" RX? Will certain patients with binocular problems and learning difficulties be missed with these refractors?

In the same poll others had these feelings:

> "There is a lot more to optometry than refraction. Yet most of our time is spent doing just that. By reducing time with refractors, we may spend more time with other necessary tests often disregarded because of a time factor."
>
> "There are times I would like to have something to check my findings against. Take the beginning cataract or macular dystrophy case."

> "With the emphasis on national health care, optometrists will have to examine more patients, automation will provide the means."[18]

Further examples of how to utilize paraoptometric personnel are illustrated in tables 4, 5, and 6.[19]

The author of these examples directed his attention to what kind of space is needed to do a reasonable job.

The authors main points were the following: The ideal would be to minimize patient movement with two complete rooms.

"Impressive, efficient, and time saving is the two examining room system. Expensive, yes, but in many practices it may be well worth it . . ."

The second room need not contain a complete duplication of equipment. Also, the technicians need a space to call their own, at least a small desk.

Finally, no matter what you assign to the technician you must calculate "time blocks" of duties and then plug them into your system where maximum time savings occur.[20]

The result of a questionnaire in Indiana concerning the duties optometrists felt a technician *must* be trained to perform, illustrated interesting attitudes.[21] 81% and 95% of the respondents listed as "necessary" receptionist and dispensing duties, respectively. They found training in keratometry and tonometry undesirable. (25% and 24% respectively find it necessary.)

Some felt that if the optometrist turns procedures over to the technician, he was apt to find that he was "out of touch with the patient".

The implications of this study suggest these optometrists were not prepared to extend duties into areas they considered as procedures requiring professional judgement.

This issue really comes down to the effect technicians will have on the quality of vision care. Doctors are concerned with the skill, and reliability of the technician and effects on the doctor-patient relationship.

The patient requires understanding, support and satisfaction to remain confident.

It has been shown that well-trained paraprofessionals can develop a comparable relationship. One study of nurses showed they overlooked only 5% of the variables physicians found, yet none were deemed significant.[22]

Others believe that repetitious utilization of their particular group of tasks will make the technician as good if not better as the optometrist in delivery of their functions.[23] This assumption is that the technicians will be highly skilled and responsible for their particular skills, including personalized attention and care. Obviously, it is necessary that quality control in enrollment and training of paraprofessional personnel be established.

Resistance stems from the desire not to lose control of the system. "The introduction of assistants into optometry will cause optometrists to re-examine their territorial imperitives and sources of satisfaction and powers."[24]

This point goes beyond ego, for it is difficult to alter the professional's way of practice after he has been socialized and indoctrinated to accept the traditional role.

It is possible that dividing the role of the optometrist, by allocating areas of measurement, and analysis to aids may rob the optometrist of rewards and motivation that drew him to the profession originally.

A *presumed* less challenging aspect of optometry may be just the factor that gives dimension and significance to the *whole*. One must question whether it is truely satisfying to work only at one's presumed highest skill level? For many the introduction of automation and technicians deny valued relations with a patient which will be lost if 30 patients are seen per day.

The automated office of the future will require new approaches to office design and employ at *least* two technicians. This will be necessary because costs must be overcome by increased patient load. The extra space and technicians will allow "flow" of patients. While one technician is performing pre-professional work another is preforming post-professional duties.

The end result is that the office must be arranged and staffed in such a manner that "bottle-necks" do not occur, slowing patient movement.

If automated, the optometrist becomes dependent upon the technician. The expansion of staff will require the profession to keep pace with effective management and office administration much more than today.

If organized into unions the cost of skilled technicians would create further management problems. Also, an automated office will not function effectively unless the technicians are utilized efficiently. This involves delegation of duties and supplying the working space necessary to preform their duties.

The optometric profession has not yet been formally trained to utilize ancillary personnel. Utilization of aids is not effective if the doctor "double checks" *all* findings or interfers with an aids functioning. The doctor must be educated to delegate responsibilities effectively.

TABLE 2

PATIENT FLOW WITH VISION ANALYZER

	RECEPTION ROOM	TESTING ROOM	REFRACTION ROOM: Technician	REFRACTION ROOM: Doctor	CONSULTATION ROOM	DISPENSING ROOM	TOTAL
	History	Field Screening Tonometry Blood Pressure Lensometer	Insert Old RX Visual Acuity Habitual Phoria Steropis	Refraction Binocular Testing	Consultation Ophthalmoscopy	Dispensing	
Doctor's Time (minutes)				5	10		15**
Technician's Time (minutes)	5	15	5			15*	40

PATIENT FLOW BEFORE VISION ANALYZER

	RECEPTION ROOM	TESTING ROOM	REFRACTION ROOM: Technician	REFRACTION ROOM: Doctor	DISPENSING ROOM	TOTAL
	History	Field Screening Tonometry Blood Pressure Lensometer	Visual Acuity	Refraction Binocular Testing Ophthalmoscopy Consultation	Dispensing	
Doctor's Time (minutes)				25		25
Technician's Time (minutes)	5	15	2		15*	37

* Second Technician

** This allows 10 minutes between patients to catch up on incidentals (phone calls, contact lens checks, complaints, office visits, etc.) and still see 20 full appointments per 8 hour day.

TABLE 3

ECONOMIC IMPACT OF THE VISION ANALYZER (HYPOTHETICAL PRACTICE)

	Previous to VA	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 1(
1. Patient Load (Number per day)	9	12	12	12	12	12	12	12	12	12	12
2. Basic Exam Fee	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
3. Practice Days Per Year	250	250	250	250	250	250	250	250	250	250	250
4. Exam Fee Increment (1)		$15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
5. Dispensing Increment (1,2)		$28,125	28,125	28,125	28,125	28,125	28,125	28,125	28,125	28,125	28,125
6. Preventive Maintenance & Insurance		$125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125
7. Property and Sales Tax		$1,400	450	400	350	300	250	200	150	100	50
8. Cost of Lease		$6,410	6,410	6,410	6,410	6,410	6,410	6,410	6,410	6,410	6,410
9. Net increase in after tax income (3)		$22,815	17,300	16,485	15,820	14,135	21,655	21,695	20,820	20,860	20,895

(1) Additional yearly receipts due to incorporation of Vision Analyzer.
(2) Based on $50 average gross margin on 75% of additional patient load.
(3) Free and clear income after expenses and taxes

TABLE 4

Utilization of Paraoptometric Personnel
Optometrist and One Technician

Patient #1		Patient #2	
TECHNICIAN Preliminary interview Visual skills Visual acuity Hypertension screening While optometrist begins patient #1, neutralizes old RX	Block I		
OPTOMETRIST Additional case history Keratometry Ophthalmoscopy Biomicroscopy Visual analysis Preliminary consultation	Block II	TECHNICIAN Preliminary interview Visual skills Visual acuity Hypertension screening While optometrist continues with #1, neutralizes old Rx of #2	Block I
TECHNICIAN Color vision Tonometry Visual fields screening Further testing field if needed Additional testing as directed Frame selection	Block III	OPTOMETRIST Additional case history Keratometry Ophthalmoscopy Biomicroscopy Visual analysis Preliminary consultation	Block II
OPTOMETRIST Final consultation and patient education	Block IV	TECHNICIAN Color vision Tonometry Visual fields screening Further fields testing, if needed Additional testing as directed Frame selection	Block III
TECHNICIAN Now with patient #3		OPTOMETRIST Final consultation and patient education	Block IV

TABLE 5

Utilization of Optometric Aides

Assistant	Technician #1	Technician #2	Lab Assistant	Optometrist
Opens office, gets work ready for the day. Preliminary information on Patient #1.			Checks jobs from lab. Orders Rx's from previous day.	
Handles mail and third party forms, sends vision reports forms, etc. Receives VT and CL patients.	Trains patient on insertion and removal of contact lens.	Patient #1 Visual skills and field screening, tonometry or NCT, checks blood pressure, keratometry, color vision	Lab work, repairs and adjustments.	Second visit for a contact lens patient.
Receives Patient #2, other front office duties, recalls, etc.	Continues education about contacts with patient just seen by doctor.	Patient #2, same as above.	Neutralize Rx on Patient #1.	Examination and vision analysis. Patient #1 consultation.
Patient #3 and new CL patient. Financial arrangements for Patient #1.	Conducts vision training session as directed.	Dispenses Rx from previous week.	Frame selection on Patient #1.	Patient #2 as above.
Continues reception duties for dispensing and other patients.	Continued vision training session.	Patient #3 Preliminary data collection.	Frame selection Patient #2, frame repair and adjustments.	New contact lenses patient work up.
As above and financial arrangements Patient #3.	Completes records for VT and CL patients.	Dispenses Rx.	Check frame samples, lab work, adjustments.	Patient #3
Lunch	Relieves assistant during lunch.	Frame selection on Patient #3.	Lunch	Completes records for patients seen and writes prescription.
Phones patient for deliveries recalls, completes paperwork	Lunch	Lunch	Orders Rx's verify day's deliveries.	Lunch

(Afternoons can be a duplicate of time blocks with variation in assignments.)

TABLE 6

Utilization of Optometric Aides

Optometric Assistant	Optometric Technician	Doctor
Opens office and prepares work for the day.	Uses time to take care of other duties and prepares equipment for use.	May not arrive at office until Patient #1 is ready for him, or may use the early time to take care of other duties.
Regular office duties, reception, telephone, recall, mail, etc.	Patient #1 Takes preliminary history, visual skills, visual acuity, color vision.	Prepares for day's work, goes over patient records completes details from previous day if necessary.
Patient #2 Collects information for office records and fills in necessary forms.	Checks in jobs from labs, order jobs, performs other essential duties.	Patient #1 Elaborates history, examination for pathology, vision analysis, prescription, consultation.
	Patient #2 Preliminary history, visual skills, visual acuity, color vision.	
Regular office duties, recalls, billing, etc. Preliminaries on Patient #3.	Patient #1 Frame selection. Adjustments for other patients.	Patient #2 History, examination for pathology, vision analysis, prescription, and consultation.
Financial arrangements and future appointments for Patient #1	Patient #2 Frame selection. Preliminary work with Patient #3.	Progress reports for contact lenses or regular patients.
Complete office work for Patient #2.	Training contact lens patient.	For Patient #3 Providing necessary professional services.

Schedules continue with appropriate breaks or even shift of duties as best provides patient service.

PATIENT RESPONSE AND ACCEPTANCE

In the setting of the automated mode, will the patient feel he is receiving quality vision care? A study of public attitudes toward the automated instramentation and acceptance of technicians revealed that willingness was dependent upon the endorsement of the family physician. It was reservation on the part of the physician which fortified public resistance.[25]

Another study, showed highest acceptance among the better educated middle-income group. The lower and upper-income groups tended to prefer treatment by the physician only.[26] These studies reveal that values, attitudes and beliefs held by the professional will manifest themselves as barriers to utilization of new types of instramentation and personnel.

It seems that ultimately acceptance will rest upon programs of orientation and education of both the optometrist and the public. Fear of the unknown is a major barrier to public security. In a world racing toward automation in every aspect of life, the public will continue to be apprehensive about change in areas of personal health.

AUTOMATION AND THE INDIVIDUAL OPTOMETRIST

Of critical importance is a definition of the role of optometry. Will it remain static or become modified along with continuing developments in technology and science? Is optometry willing and able to redefine its boundaries of activity? Defining optometry's role is a difficult task, due to diverse views within the profession and the absence of a coordinated division of activity with the profession of ophthalmology and other overlapping professions.

Will optometry broaden its scope of service, de-emphasizing selling and dispensing aspects of the refractionist role and establish a new professionalism encompassing new diagnostic and therapeutic advances?

In May of 1975, the AOA published the results of its Delphi program. Which was a refined method of making forecasts based on expert opinion. The study included the individual responses of optometric educators, executives, practicing doctors and student leaders. The participants did not inter-communicate. Many of the results can be used to forecast attitudes and future trends in role definition. (See Table 7)

By 1985, 40% predicted that more than half of practicing optometrists will be using "automated diagnostic" equipment, and 50% predicted a central computer diagnostic service nationwide. 90% felt central-accounting systems would be available also.

Forty percent predicted less than one-third of all practicing optometrists will be in solo practice in 1985. With 60% feeling one-fifth of the future optometrists will be in inter-professional group practice.

Seventy percent felt *all* states would permit the use of pharmaceutical agents for diagnostic purposes and 80% predicted therapeutic use in at least one state by 1985. (As of August 1, 1977, fourteen states had enacted legislation authorizing optometrists to utilize diagnostic pharmaceutical agents. Optometrists in West Virginia and North Carolina as of June 1977 are also authorized for use of specified therapeutic pharmaceutical agents.)

Of the participants, 60% predicted National Health Insurance, including full scope optometric care, available to all age groups would be available. Finally, 90% felt utilization of paraoptometric personnel would double by 1985. [27]

It is important to note, that of the five groups participating, the *practicing* optometrists correlated highly with the overall predictions.

Students; however, were more conservative in areas of automation and the predicted reduction of the solo practice than practicing doctors. A different survey of student opinion concluded that most students favored solo practice, specialization (especially contact lenses, optometric pediatrics, and visual training), and independence from other *visual* care professionals. [28]

These opinions of the students may change with further experience and approximate the feeling of the practicing optometrist.

In 1968, the National Center for Health Statistics reported 88% of active optometrists as self-employed and in 1973, 77% self-employed. Of these professionals, 74% were in solo practice in 1968 and 62% in 1973. [29]

A New York study found 79% of all active optometrists were self-employed but only 56.2% were in solo practice. [30]

These figures indicate a shift away from solo-practice. This can be partly due to the passage of legislation enabling optometrists to incorporate. In 1973, 22% of salaried optometrists were part of a professional corporation as opposed to 4% in 1969. Furthermore, the proportion of optometrists who are self-employed is the highest in the 30-34 years-in-practice catagory (87.5%). As these optometrists leave the profession, the trend toward group practice will seem to increase.

Finally, 4% of the active optometrists in the Pacific region are in a multidisciplinary group and the number of practitioners employed by an ophthalmologist have increased among young optometrists. [31]

In the New York study, 17% practiced out of two locations and 3% practiced in three or more offices. "An inverse relationship appears between age and the number of practice locations. Younger practitioners are more likely to maintain more than one office. Forty-four percent of all optometrists less than 30 years of age practiced in more than one office as compared to 20% of those over the age of 50 years. [32]

As a whole, these surveys and manpower statistics tend to support the attitudes needed in a trend toward automation and expanded scope of service. (See Table 8)

TABLE 7

AMERICAN OPTOMETRIC ASSOCIATION
DELPHI PROGRAM

FUTURE OF OPTOMETRIC PRACTICE

C - Optometric College Administrators and Faculty
E - Optometric Association Executives
L - Optometric Leaders
P - Prominent Practicing Optometrists
S - Optometric Student Leaders
COMB - Combined

1. Less than one-third of all practicing optometrists will be in solo practice by 1985.

C	E	L	P	S	COMB.
.35	.50	.33	.39	.60	.43

40% Probability Predicted

2. At least 20% of practicing optometrists will be in inter-professional group practice by 1985.

C	E	L	P	S	COMB.
.58	.68	.70	.54	.53	.61

60% Probability Predicted

3. More than 50% of practicing optometrists will be using "automated diagnostic" equipment by 1985.

C	E	L	P	S	COMB.
.39	.57	.43	.40	.28	.42

40% Probability Predicted

4. Central computer accounting systems will be available to all private practitioners nationwide by 1985.

C	E	L	P	S	COMB.
.85	.81	.88	.87	.71	.83

90% Probability Predicted

5. Central computer diagnostic services will be available to all optometrists nationwide by 1985.

C	E	L	P	S	COMB.
.44	.53	.55	.66	.55	.55

50% Probability Predicted

6. All states will have passed enabling legislation or will have found other legal means for permitting optometrists to use pharmaceutical agents for diagnostic purposes by 1985.

C	E	L	P	S	COMB.
.77	.58	.68	.60	.72	.67

70% Probability Predicted

TABLE 7 (continued)

7. "National Health Insurance", including the full scope of optometric care, will be available to all persons regardless of age by 1985.

C	E	L	P	S	COMB.
.59	.56	.45	.72	.56	.57

60% Probability Predicted

8. Utilization of paraoptometric personnel by optometrists will be doubled by 1985.

C	E	L	P	S	COMB.
.82	.80	.90	.92	.92	.87

90% Probability Predicted

9. Optometrists will be required to perform some general health screening (i.e. blood pressure) on patients by 1985.

C	E	L	P	S	COMB.
.67	.59	.57	.57	.61	.60

63% Probability Predicted

10. Commercialism in optometry will have disappeared by 1985.

C	E	L	P	S	COMB.
.19	.14	.18	.25	.18	.19

15% Probability Predicted

11. By 1985 at least 25% of practicing optometrists will not engage in dispensing materials.

C	E	L	P	S	COMB.
.56	.73	.63	.69	.77	.68

70% Probability Predicted

12. Optometric specialities will be recognized and specialists certified by an independent national board of certification by 1985.

C	E	L	P	S	COMB.
.54	.72	.69	.64	.53	.63

70% Probability Predicted

13. Price advertising by all health professions will be legal in all states by 1985.

C	E	L	P	S	COMB.
.44	.42	.53	.39	.17	.40

40% Probability Predicted

Bailey, J.H., AOA Delphi Program: Future of Optometric Practice, J.A.O.A., 46 (5): p 547-552, May, 1975.

TABLE 8

DISTRIBUTION OF LICENSED OPTOMETRISTS		
Region	Per Cent of Resident Population	Per Cent of Licensed Optometrists
Northeast	24	25
North Central	27	30
South	32	24
West	18	21

MEDIAN AGE OF OPTOMETRISTS BY TYPE OF PRACTICE AND REGION	
Type of Practice	
All Forms	49.4
Solo	51.1
Partnership	46.2
Group	47.4
Employee	42.9

AGE OF ACTIVE OPTOMETRISTS	
Under age 30	9%
Age 30 to 39	16%
Age 40 to 49	28%
Age 50 to 59	32%
Age 60 to 69	11%
Age 70 +	4%

ACTIVITY STATUS AND LOCATION OF LICENSED OPTOMETRISTS

Total	Active	Inactive	Retired	Not Retired
21,697	19,265	2,432	1,217	1,215

OPTOMETRY, COMPARED TO OTHER HEALTH PROFESSIONS

	Optometry	Medicine	Dentistry	Osteopathy	Pharmacy
Number of Practitioners	19,265	330,000	112,020	15,000	130,000
Number of Schools	15*	114	59	9	72
Number of 1975 graduates	906	11,613	4,969	695	6,712

* Includes two Canadian schools of optometry

TABLE 8 (continued)

U.S. POPULATION: 1975 - 1985						
	Estimated 1975 Population (in millions)			Projected 1985 Population (in millions)		
Age Group	Men	Women	Total	Men	Women	Total
0-14 Years	27.3	26.3	53.6	24.7- 31.2*	23.3- 29.7*	48.0- 60.9*
15-19 Years	10.7	10.4	21.1	9.1	8.9	18.0
20-24 Years	9.7	9.6	19.3	10.3	10.2	20.5
25-34 Years	15.3	15.6	30.9	19.8	20.0	39.8
35-49 Years	16.9	17.8	34.7	21.0	21.9	42.9
50-64 Years	15.1	16.6	31.7	15.5	16.9	32.4
65-74 Years	6.0	7.8	13.8	7.0	9.3	16.3
75 + Years	3.2	5.4	8.6	3.6	6.6	10.2
TOTAL	104.2	109.5	213.7	111.0- 117.5*	117.1- 123.5*	228.1- 241.0*

* In the population projections for 1985, two figures are shown for the 0-14 age group and for the total. This range allows for possible variations in birth rates during coming years and, thus, for variations in the number of children under 10.

FREQUENCY OF EYE EXAMINATIONS AMONG WEARERS OF CORRECTIVE LENSES			
Frequency	Among People Who See Optometrists	Among People Who See Ophthalmologists	All All People
Two or three times a year	7%	15%	10%
Once a Year	40%	41%	41%
Every Two to Three Years	38%	37%	37%
Less Than Every Three Years	10%	6%	8%

TABLE 8 (continued)

OPTOMETRIC PATIENT LOAD: VISUAL EXAMINATIONS	
Patients/Week	Per Cent of Optometrists
0 to 10	5
11 to 20	19
21 to 30	31
31 to 40	21
41 to 50	12
51 +	8
Don't Know	4
Median	30 Patients
Mean	33 Patients

OPTOMETRIC PATIENT LOAD: OTHER PROFESSIONAL SERVICES	
Patients/Week	Per Cent of Optometrists
0 to 20	20
21 to 40	35
41 to 60	19
61 to 80	5
81 to 100	7
101 +	12
Don't Know	2

Panel Report, Ophthalmic Almanac and Forecast, Review of Optometry, 115 (1): p. 49-55, January 15, 1978.

FUTURE ROLE AND SCOPE OF OPTOMETRY

If the trends continue to build, what impact can be expected on the role and scope of practice?

Some believe that by 1985, optometry's emphasis should be on the prevention of eye and vision problems. Minimum care will not be enough to maintain the profession.

If the profession pursues an expanding scope of service, its role in national health insurance will be at a primary entry point which can provide services at lower real costs than ophthalmology and free higher-priced ophthalmologists to do the specialized work for which they were trained. [33]

National health insurance may place emphasis on HMO's and other Health Management-type organizations.

It seems highly likely that by 1985 about 30 to 35 percent of medical practice will be carried on by HMO's. [34]

Some feel the prospects of national health insurance are becoming more remote.

One reason, according to the Congressional Budget Office is continued and uncontrolled health care costs, combined with cost overruns and financial scandals in the Medicaid and Medicare programs. That no effective cost containment policy is in effect for existing programs makes the likelihood of a major legislative effort remote.

It seems that the Carter Administration has adopted two priorities. The first is cost containment and the second to encourage forcefully the development of alternate systems of health care delivery, particularly that of the HMO.

Optometry must forcefully obtain inclusion in this consolidation effort, then a critical historic moment for our profession will have passed.

The government is likely to liberalize loan guarantee provisions for HMO's. Therefore we must fight to guarantee inclusion in development of HMO regulations. Optometry must also solve problems in professional placement, interprofessional relationships, and our role in HMO's. [35]

Optometry must play an integral part in HMO's and other evolving health care delivery systems. In many communities one can visit an optometrist in the same office of a physician or dentist. HMO's have found it cost-effective to utilize OD's for primary eye/vision care. [36]

The Carter administration is emphasizing HMO's and such federal programs as CHAMPUS and FEHBA are joining Medicaid and Medicare in utilizing these delivery systems.

It has been shown that it is cost-effective for an HMO or health center to maximize the use of optometrists in providing eye/vision care services. [37]

The ready accessibility of the skills of optometry as an adjunct to internal medicine and pediatrics provides for enhanced patient care.

Optometry is recognized in the Health Maintenance Act of 1973 as a logical member of a multidisciplinary group practice. There are also provisions for including optometrists as members of the medical group sponsoring an HMO.

A case to the point:

The following statistics were taken from a four-year experience of operation of the Genesee Valley Group Health Association (GVGHA) in Rochester, New York. The group has a membership presently of 32,000 patients.

> The largest portion of eye/vision care delivery is functional visual care (70.6%). This includes correction of refractive errors through objective and subjective refraction (54.6%), contact lens

fitting (14.6%), the correction of functional extraocular muscle imbalances through visual training and enhancement of subnormal vision through telescopic systems (1.4%).

The next major portion of eye care delivery consists of ocular health (27.9%) which included subacute and chronic eye infections and inflammations, ocular trauma, and the ocular manifestation of systemic disease.

The final segment of eye care delivery includes surgical eye care (1.5%).

Form of Care	Delivered by OD	MD	%
A. Functional			
1) Refractive	Yes	Yes	54.6
2) Contact Lens	Yes	Yes	14.6
3) Vision Training,	Yes	No	
Subnormal Vision,	Yes	Yes	
and Developmental Vision	Yes	No	1.4
B. Ocular			
1) Preventive	Yes	Yes	16.7
2) Acute	Yes	Yes	5.6
3) Cronic Anterior Segment	Yes	Yes	2.8
4) Chronic Posterior Segment	No	Yes	2.8
C. Surgical			
1) Elective Surgery	No	Yes	0.9
2) Sight-Saving Surgery	No	Yes	0.6

Applying the following options for eye care delivery to the above table shows how real and increasing dollar savings may be made by maximum utilization of optometrists rather than ophthalmologists. The dollar figures assume an average OD annual income of $30,000 and an average ophthalmologist annual income of $80,000, utilizing the equivalent of one eye/vision care professional (OD, MD, or combination to provide services to a unit of 12,000 enrollees in a 12 month period.

Type 1: Optometry is not utilized, total cost $80,000 for one year.

Type 2: Optometry utilized to provide refraction care only (54.6%), total cost $52,700.

Type 3: Optometry is utilized to provide not only refractive care (54.6%) but also preventive ocular care (16.7%). Total cost is $43,350 for one year.

Type 4: Optometry adds the remaining aspects of functional care, i.e., contact lens (14.6%) plus vision training, subnormal vision and developmental vision (1.4%) for a total of 87.3%. The total cost is 36,350 per year.

Type 5: Optometry adds care of acute and chronic anterior segment ocular care (8.4%) or a total of 95.7% for a total cost of $32,150.

Thus, increased utilization and increased scope of delivery of optometry services (primary care optometry) is extremely cost-effective in a multidisciplinary practice. [38]

If we project the results of the above discussion to an HMO serving 120,000 patients, the following occurs:

Type	Cost of Plan	Delivered Savings/Year
1	$800,000	
2	527,000	$273,000 (over 1)
3	433,500	366,500 (over 1)
		93,500 (over 2)
4	363,500	436,500 (over 1)
		163,500 (over 2)
		70,000 (over 3)
5	321,500	478,500 (over 1)
		205,500 (over 2)
		112,000 (over 3)
		42,000 (over 4)

Now think of the savings if this model were projected onto the United States as a whole.

Optometry must look at what other professions are doing in efforts to alleviate manpower problems they face.

If the fruits of technology are to be utilized within the expanding role of vision care, and still provide cost-effective comprehensive care the optometrist must assume a larger clinical role within a team. Not only in private groups, but in clinics, centers, and hospitals.

It is not expected that the optometrist of the future will be in a solo general practice. In such a setting an extra benefit will be immediate consultation and referral sources within the group or clinic.

A final role change is that increased knowledge and automation forces specialization of services. Sepcialization allows for greater skill within one's particular area of work, but also reduces one's adeptness in certain areas within the expanding profession. This will create problems should no attempt be made to integrate the activities of various specialities.

INTERPROFESSIONAL RELATIONS

Not only will optometry require greater internal organization, it will need improved cooperation with the other vision professions.

Ophthalmology is concerned that optometry desires to move into the area of definitive diagnosis and treatment while optometry feels an attempt to be eliminated by ophthalmology through utilization of technically trained personnel.[39]

The situation is not in the interest of either profession or the public. A defining of skills is needed with greater interprofessional education and research.

The role of both professions in NHI was discussed previously.

Regardless of the form of organization, implementation of the health *team* concept has accelerated. In such a team, the physician has felt a traditional or inherent right to rule. However, in an organized setting on a prebudgeted payment mechanism, competition for fees could fade out. Under these circumstances, cohesiveness and recognition of responsibility will grow. The role of each member of the team will expand to its fullest potential for his particular visual skills.

On a budget, the cost-concious team will not spend its resources for more costly members to do a particular task if the role can be filled at a lesser cost.

Finally, just as the ophthalmologist in the above model was substituted by the less expensive optometrist, so could the optometrist be displaced in certain tasks by a technician, and the technician by an automated instrument.

COST: MONETARY

The expense of an automated office is relative to the commitment to new instruments, computerization, and numbers of technical personnel above present levels.

Presently, an automatic objective refraction instrument would cost between 15,000 to 30,000 dollars. Most would consider this beyond the potentials of their office. However, it is pointed out that this instrument alone, "could provide one-and-one-half hours per day in saved time, (extra-patient potential), and make extra data available more rapidly. This would allow the optometrist to preform his job faster." [40]

Another author arrived at the *same* conclusion, but for a highly automated office. The article poses a hypothetical figure of annual overhead of $250,000, yet projected a cost to the patient of $27.75 - less than currently charged for professional services in many places.

Again, the reduction is due to *productivity*. The example illustrated a two-doctor clinic staffed with trained technicians. It proposed a doctor would see 30-35 patients per day. [41]

It was found, that present-day optometrists were willing to pay a "schooled optometric technician with one *years* experience between $3,852 to $6,218 each year. These projected salaries seem to be competitive with other ancillary health personnel requiring two years training." [42]

Studies do indicate that increased productivity would overcome present levels of technician expense and costs of increased office space. [43]

Finally, the monetary expense of computers has traditionally been conceived as too expensive.

Today; however, the word computer refers to an entire tribe of devices from desk-top calculators to giant IBM-type installations. In between there are mini-computers which can be programmed for a large variety of functions and "dedicated" computers designed to carry out specific functions.

Surprisingly, all the above computers are economically feasible in optometry.

"At least two different mini-computers are currently available for less than $1,000 each. They are capable of being programed, by means of a simple mnemonic language, to preform automatically in excess of 130 sequential program steps. The versatility is developing rapidly and models having even wider range are expected in the near future." [44] The circuits of thes computers are currently mass-produced at low costs. Calculators costing $500 five years ago, today sell for less than $150.

In a recent article, a Pacific University thesis group created programs (Optometry Pack) for the Hewlett-Packard HP-67 and HP-97 programable calculators. These two calculators are very similar to minicomputers: they allow an O.D. to write, record and run his own programs.

Each program is recorded and stored on an easily accessible magnetic card. The Visual Sciences covered in the Optometry Pack includes: Ophthalmic optics (8 programs), Contact lenses (14 programs), Aniseikonia (2 programs), Low Vision (4 programs) and Case Analysis (3 programs). Each of the categories in the $45 pack are $10 separately.

Hewlett-Packard also have programs for business, invoicing, payroll, inventory, and statistics. All programs will be valid in future models and buyers may obtain other ideas from HP's programing booklet and User's Library. [45]

A new system by Management Data Sciences, the MDS Systems 10 contains 24,000 individual bytes in a semiconductor memory and a dual floppy disc memory which can hold an additional *million* characters per disc.

The programs designed for optometry and ophthalmology include (1) personalized recall letters and status input, (2) accounting system to give instantaneous history of a patient's account, (3) personalized billing letters, (4) cash flow analysis, and (5) complete management profile. Cost $22,000. [46]

Even the large IBM-type systems can be utilized by the practitioner at a reasonably low cost. This is made possible by the existence of remote terminals and time sharing. Terminals connected to the main computer installation by telephone may be leased or bought at about $1500.

Time sharing means that a number of users can use the computer at the same time, so that cost of running the computer is shared by all. The running cost should be no more than the salary paid to a senior office assistant.

"To run such a program, the user needs only the ability to type. He does not need to know anything about how the program works or how the machine operates." [47]

It can be concluded, that mass production, time sharing and increased productivity may potentially overcome the monetary costs of automation.

The monetary aspects of new instruments are evidently not the primary concern with optometrists. More and more doctors of optometry are buying instruments.

A majority of O.D.'s own slit lamps and sphygmomanometers, and others utilize radiuscopes, special V.T. devices, fundus cameras and screening devices.

In general, optometrists seem satisfied with the service and quality of the instruments they purchase. When polled many indicated they look for quality first. Most important is whether the instrument can do what it was designed for. Next, they looked at service, and only then did price, advice from others, and availability figure into their final decision.[48]

For a more in depth review of how computers can influence optometry, see Appendix I of this thesis!

COST: PROFESSIONAL (WILL OPTOMETRISTS ACCEPT AUTOMATION)

In a recent article, Oregon optometrists were asked what research areas most practitioners felt were most important for consideration.

It becomes quite apparent from the table (Table 9) that a priority was on the evaluation of new equipment and techniques with second priority going to vision training, developmental vision, contact lenses and case analysis. The lowest priorities were for research in dispensing and practice management. These priorities reflect the changing nature of optometric practice and reflect attitudes aimed at getting a grasp on new instrument utilization.[49]

Along similar lines, responses from a national poll provide insights as to the kinds of instrumentation optometrists would like to see develop.

Heading the list was an ophthalmometer that could measure peripheral, as well as central cornea. Others desired better instruments for measuring and checking soft lenses. Another would like a fundus camera, reasonably priced, and not requiring dilation.

When quizzed about computer technology, optometrists had many ideas. One idea was to improve the Humphrey Vision Analyzer and then hook it up by telephone to three or four other doctors. Also, an automated lensometer could be run through the same computer, cutting costs dramatically. Other ideas ran from calculators for optometry to centralized information banks on patients.[50]

The interesting conclusion from such comments is that it becomes clear that optometrists do not fear improved or automated instrumentation, but the use of such devices in a manner which would detract from the patients total visual needs or be used in an "unethical" manner. (See Table 10)

TABLE 9

RESEARCH PRIORITIES

First Priority	Second Priority	Third Priority	Lowest Priority
New equipment and techniques (26%)	Contact lenses (19%)	Contact lenses (19%)	Dispensing (41%)
Vision training and developmental vision (17%)	New equipment and techniques (15%)	Vision training and developmental vision (16%)	Practice management (16%)
Pathology (12%)	Vision training and developmental vision (15%)	Pathology (15%)	Electodiagnosis (10%)
Contact lenses (12%)	Electrodiagnosis (13%)	New equipment and techniques (13%)	Case Analysis (8%)
Electrodiagnosis (11%)	Practice management (10%)	Electrodiagnosis (10%)	Vision training and developmental vision (7%)
Practice management (4%)	Case analysis (8%)	Practice management (9%)	Pharmacology (5%)
Low vision (2%)	Low vision (7%)	Pharmacology (6%)	Pathology (4%)
Pharmacology (2%)	Pathology (6%)	Low vision (5%)	Low Vision (4%)
Dispensing (1%)	Pharmacology (4%)	Case analysis (5%)	New equipment and techniques (2%)
	Dispensing (2%)	Dispensing (2%)	Contact lenses (2%)

TABLE 10

Do you favor or oppose automation?

Favor	44.4%
Oppose	33.1%
Don't Know/No Answer	8%

How will automation affect the efficiency of care in the next 20 years?

Improve it greatly	15.6%
Improve it some	45.6%
Not effect it	23.2%
Decrease it some	8.4%
Decrease it greatly	1.5%
Don't Know/No Answer	1.9%

How will automation affect the quality of care in the next 20 years?

Improve it greatly	3.0%
Improve it some	30.8%
Not affect quality	28.5%
Decrease it some	17.9%
Decrease it greatly	4.6%
Don't Know/No Answer	.4%

Percentage of optometrists who have the following instruments?

Automated Refractors	3.0%
Automated Field Tester	12.5%
Fundus Camera	4.9%
Radiuscope	39.9%
Slit Lamp	88.2%
Sphygmomanometer	61.2%
Vision Trailing	49.4%

(Blake, Barbara, Panel Report: Automation: Will it Click with Today's O.D.?, Review of Optometry, 115 (3): p. 65-68, March 15, 1978.)

CONCLUSION

Whether automation is feared or welcomed, can only be answered by the individual optometrist. Each practictioner must decide within his own framework of personal bias and expectations how automation will influence his needs. Finally, after deliberating the many aspects involved, he must also decide how automation will influence the quality of care for the public he serves.

Optometry faces a scientific and technical challenge which can become an opportunity to develop *full-scope* vision care. The profession has been quick to adapt in the past and must be aware that other professions will not remain static even if optometry chooses to do so.

Potential manpower shortages, coupled with public and government demands make greater utilization of advancing automated techniques and efficient use of paraoptometric personnel inevitable.

The problem today is *time*. Never before has automation shrunk the time span of advances to such a degree. Yesterday, one could be secure that change would not be so rapid as to force drastic personal changes in anticipated style of practice.

However, yesterday technology advanced on a time scale of years, today it is weeks. The graduate of today can expect radical changes to influence his life before he retires.

These changes in society, government, and industry have not allowed sufficient time for sociologists, psychologists and other behavioralist to study the potential adverse implications of change on the expectations and satisfactions of the public or profession.

The key to reducing fear is *education*. Through education, the student of optometry can be taught how to anticipate and utilize automated instruments. Also, the public must be educated as the possbile benefits.

Maximum health care delivery will result *only* if the education and delivery processes are coordinated and cooperative. We must maintain an open mind to change, not for the sake of change alone, but to the potentials it brings to total vision care for society. If optometry as a profession is able to accept change, the end result will be a more expanded and vibrant profession, capable of meeting challenge!

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THE USE OF COMPUTERS IN OPTOMETRY

Appendix I

Monte Gallinger

A discussion of automation in optometry would not be complete without a more detailed study of the role computers will play in the present and future of optometry. The purpose of this section will be to provide the reader some basic information concerning "computer" systems, discuss a few of these systems the author reviewed and their role in optometric applications. The scope will be limited to computer devices just superior to the programmable calculators in ability and end before the larger computer systems which for clinical optometry could only be labeled "overkill". Billing, clerical, and paper pushing will only be mentioned briefly where they apply. Information concerning these accounting systems can be fully realized by contacting any computer supplier who has designed these systems for medicine. In fact much research and development has taken place for accounting systems for medicine, dentistry, and are also applicable for optometry also. However, optometric clinical data as recorded by the optometrist, the twenty-one point exam, very definitely lends itself to computer analysis. Computer systems will aid the optometrist in organizing data, provide patient records for immediate recall, very quickly display any graphical analysis desired, normative or O.E.P. analysis, and will provide more information quickly thus enabling the doctor to better utilize his time in using his professional judgement in therapy programs instead of number crunching. Therefore, the major thrust will address optometric clinical data analysis for the practitioner using a systems approach and will remain as non-technical as possible.

This writer highly recommends a course in basic computer programming for every optometrist and urges optometry schools to include this as an elective course, if not a required course. A course such as this is offered at almost all american universities and will teach the student how to program. Then by understanding how to communicate with the computer, no matter what computer device (hardware) is purchased, the optometrist can write his own programs (software) to meet his specific needs. Of course prewritten "canned" programs can be purchased and with time will become more available for many different uses in optometry. At this time, since optometric use of computers is essentially non-existent for the private practitioner, very few general programs are marketed. During this author's search of IBM, Hewlett-Packard, Tectronics, and Processor Technology, no programs for optometric case analysis were located (programs which would work on a mini-computer), which surely isn't surprising considering the former statement. Software is available for accounting and will increase. This is where the money market for companys is located and why unless a profit can be anticipated to develop in optometric clinical analysis packages, the practitioner should be educationally armed to design his own software.

Most of us know more about computers than we think we do. The method we would use to solve a problem with pencil and paper is probably the same as the method one would use to solve the problem using a computer. The main difficulty is not in knowing what to do, but in how to communicate with the computer to get it to do what is required. We must talk to computers in their language rather than ours. Also because computers take everything literally, there is no room for error. We must use extremely precise language instructions. When a computer makes an error, there is only one person to blame--the person who gave the instructions. The computer will follow an incorrect instruction just as fast as a correct one.

"Storage" in a computer is expensive, so a discussion of how it is utilized will be helpful. One of the measures of "bigness" is the storage size of the processing unit. Storage is expressed in terms of thousands of positions of storage. A 16k memory computer would have sixteen thousand positions of memory. Each position of a computer's storage circuit can hold one numeric, alphabetic, or special character. The size of storage you require is dependent on the size of the program and the number of programs you intend to run at one time. The primary use of processor storage is to temporally store the program to be run. Usually a fairly small amount of the storage is reserved for data, and most of the space is used by the programs or instructions that operate on the data. The data in this case would be a twenty-one point exam, which would occupy a small amount of storage. The operating program which tells the computer what to do with this data would occupy considerably more. We need only access one patients records at a time so less overall memory would be needed (less monetary outlay) as opposed to having five hundred patients records available at one time, which would be very costly. Remember, this is processor storage (temporary) not disc or tape (long term) storage. Sometimes processor storage is referred to as "working" memory and disc or tape storage as "storage" memory. Processor storage would be found in the "hardware" (electronics) of the computer system, where as long term storage memory would be found in a "peripheral" tape or disc unit. Peripheral units are devices like keyboards, tape machines, disc record devices, and printers which allow the user to communicate with the main computer. Then the computer outputs the result to the user on other peripheral devices like printers or cathode ray tube (CRT) screens.

Most computers have magnetic tape devices that may be attached to them. The recording and playback will be the same as on a home recorder except that optometric data would be contained instead of music. The information on the tape can be used by the computer for input, processing, and output.

Another form of magnetic recording is done with a magnetic disc, which is somewhat like a normal phonograph record, but has magnetic coating on its two surfaces and is mounted on a disc drive device. The computer can access information from either side of the disc quickly with out "playing" the entire disc. The new "floppy" diskette is an exciting concept which works the same but looks like a forty-five rpm record and is easy to handle. Using disc devices large amounts of data can be stored in a relatively small space. Typically a single disc or tape can store from 100k to 50,000k characters depending on the computer involved.

Tapes and discs are long term storage devices in which desired portions are activated into processor "working" storage for a specific function. After the task is complete the storage information on the disc can be left as it is or rewritten (updated).

The most commonly used peripheral output device is the printer, which gives a hard copy of the data output, can be read by humans. This output looks much as a typewritten sheet would but is printed from hundreds to thousands of lines per minute.

In addition to hard copy output, the same data can be viewed on a television like screen (CRT) where a permanent record is not needed. For instance if you wished to display a patients findings for reference only, you would save paper by using a CRT.

An enormous variety of manufacturing computer system suppliers make it necessary to further discuss general system applications for optometry. Each manufacturing company has its own sales and technical personel who can assist the optometrist in designing a specific system for his needs.

Some factors considered would be: what he can afford, the amount of processor (working) storage needed, the type and amount of long term storage needed, the speed of the system (output), how easily personel can be trained to utilize the system, and what the optometrist wants the system to do for him.

This writer feels for an optometrist to have a versatile system several basic components are necessary in addition to a computer. The term "computer" can be a very general term to describe a small system or a billion dollar government system. For optometry, the term the industry uses to describe the type of system needed is "mini-computer". Generally, a mini-computer is a system which can look like a large desk top calculator or be contained in a normal size business desk, yet have full computer capabilities. In fact these mini-computers are becomming incredibly sophisticated systems and like full computer systems are primarily limited in function by the operators ability. For complex scientific research problems or large business applications, expensive computer systems with speed and large storage capacities are necessary. Fortunately in clinical optometric applications, the problems to be solved are really very simple when compared with the former. Therefore mini-computer systems can be utilized with the assurance that they will be more than adequate. The programs needed are also simplistic.

The importance of this next statement stands alone and deserves special emphasis. Almost any data processing (accounting) system sold to small business (mini-computer) which is designed for clerical work, is sufficient to perform any of the clinical optometric analysis. Usually with little or no extra expense the system can be directly utilized. Therefore if a system is purchased to do billing and clerical work, why not use it for other optometric applications? This would better use the equipment plus save time and could provide better care. At this time some extra education (possibly self taught) is all that is required of the optometrist.

When a mini-computer system is chosen some peripheral units will be required to best adapt it for optometric use. The floppy disc system is more efficient than the tape drive long term storage system and also has much more storage capability. The floppy disc system is also recommended because of its ease of use. The discs look like forty-five rpm records and are inexpensive, thus adding tremendous storage capability. Another necessary peripheral is a printer. This will allow hard copy print outs and billing forms to be produced easily. To summarize, the optometrist should have the mini-computer (usually includes a key-board for input), a printer, and a floppy disc drive for long term storage. These are the essentials and depending on the system brand chosen will also include CRT screens plus various sizes of processor memory. This system will enable the optometrist to use any form of analysis he desires, enable him to design his system to meet his specific needs, decrease clerical personel, increase his available time with patients, give him tremendous amounts of data at his fingertips, store important financial data, compute income taxes, salaries, expenses, and ease his workload once he has adapted to the system. The mini-computer system will notdecrease the optometrists role in patient care and professional judgement, but instead allow him to do what he is trained to do, to be a doctor. Computers will never completely replace vision care optometric practicioners.

Accessories that are nice add-ons if not provided as a part of the system are: CRT screens for displaying data, extra user languages for increased versatility, and game package programmes for patients while they are waiting. This list will increase with time as technology marches foreward.

Speed of execution, especially in output peripherals, is something to be considered. Some printers will print eighty lines per minute, others one thousand lines per minute, and various steps inbetween. For industry where paperwork volumn output is important, the faster the better. For optometry, the slower units will be quite adequate, still faster than humanly possible. Some mini-computers will take three seconds to compute a certain number of programs, others will do the same set if instructions in one hundred milli-seconds. Again, optometry doesn't need the super fast units. The slower units cost less generally. It would take the optometrist hours to do what the computer will do in seconds.

The basic systems consisting of mini-computer, floppy disc drive, CRT screen, can cost anywhere from seven thousand to fifteen thousand dollars at todays rate. These systems all basically do the same thing but in different ways by different companys. Maintenance is considered by some companys in the purchase price and others charge monthly fees. Specific details vary with each manufacturer and will not be discussed in this paper. Manufacturer's market reputations also figure in and are a part of american consumerism, not this paper.

We have seen the electronic revolution change all aspects of our lives. This writer is certain that computers will find increased use in the future of optometry. Would it not be better for optometrists to involve them selves with the application of computers in optometry today, instead of finding them selves dictated to later by industry?

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