Optometrists' Human and Computer Assistants

Elwin Marg, O.D., Ph.D. and Rebecca Ng, O.D.

Reprinted from J.O.M.
May, 1972, Volume 14, No. 5
pp. 357-362 and 399

Editorials

ROBERT B. O'CONNOR, M.D.
Department Editor

Computers as Physicians Assistants

The trend towards the use of computers in medicine is becoming more obvious each day. Computers are being successfully employed in recordkeeping, medical laboratories, multiphasic examinations, medical case histories, and in diagnosis, to say nothing of keeping financial and patient recall records.

To date there has been little direct interaction between the patient and the computer except for case histories because of the difficulties in communications between them. Generally, data from a physical examination or a laboratory test is fed into the computer and the data is listed for the consideration of the diagnostician. In some aspects of the health field, it appears increasingly possible that the computer may offer a tentative prescription after obtaining data directly from the patient. The most advanced development in this field appears to be in ophthalmic examinations for refractive errors (see p 357).

Recent work indicates that not only can a case history be successfully obtained directly from the patient, but also that visual acuity and an objective and subjective ophthalmic examination can be completed by computer. Pattern recognition by computer is still in a relatively primitive state, and this means that ophthalmoscopy will, for the foreseeable future, be handled by a professional. Human relations probably cannot be readily accomplished by computer. There will be need for the "laying on of hands" and the final decision to be performed by a professional.

Computer-assisted ophthalmic refraction is likely to be of particular interest to industrial physicians. The computer can be programmed to do a screening examination if desired rather than a full one. The screening examination, except for ophthalmoscopy and tonometry, can be fully automated and, also if desired, be far more complete than screening examinations have been in the past. Complete examinations can be done with the active attendance of an ophthalmologist or optometrist. Thus, time may be saved from work by complete ophthalmic examinations at the plant rather than at some distance.

It is too early to assess the costs of an automated eye examination system. An article in this issue, using clocking methods developed in industry, indicates that with maximum computer and technical assistance, an optometrist or ophthalmologist can give complete examinations to up to six times as many patients as he can alone. This is based on equal quality of the service.

Journal of Occupational Medicine
JOM
May, 1972 Vol. 14, No. 5

Optometrists' Human and Computer Assistants

See Editorial pp 399

Elwin Marg, O.D., Ph.D. and Rebecca Ng, O.D.

In all efficient fields of collective human endeavor, it is general practice to delegate, inasmuch as possible consistent with satisfactory performance, work to the less skilled, less talented, and less educated. This reserves the more difficult tasks for the more skilled, talented, responsible, or the more educated. Ideally, a system is developed which permits each individual to rise to his highest level of competence and motivation, with commensurate rewards.

These principles are clear in industry, as for example, in the production of automobiles. (Where, incidently, the increasing use of complex tools and automation has kept prices within one order of magnitude for more than 50 years despite enormous increases in performance.) They are perhaps less clear in the health sciences where traditionally the practitioners have included relatively simple aspects of their complex tasks as a part of their total service partly because of tradition, partly to provide a unified service and partly because of the difficulty in distinguishing the important from the trivial. It is difficult to distinguish in some instances, what is vital from what is important, and what is important from what is of no importance. A headache can be of little diagnostic importance or the only symptom of a brain tumor.

From the School of Optometry, University of California, Berkeley (Dr. Marg). Dr. Ng, a former U of C student, is currently a practicing optometrist.
Reprint requests to U of C, Berkeley, Calif. 94720.

In medicine, a case history or interview has always been considered a vital part of the service to a patient. The questions range from very important to almost trivial, but together form a picture of the patient's health and health problems. It was once believed that only a trained physician could take a useful medical case history because of the subtleties involved in organizing the important answers into a health picture and discarding the trivia. Now, case history taking, originally programmed by physicians, is being increasingly delegated to computers.* Determination of blood pressure and intraocular pressure, and the taking of "pap" smears and breast palpation has in the past been considered the physician's personal task as well as his responsibility because of his special training and skill and the interpretation required. There is evidence that they are increasingly being delegated to specially trained nurses and medical technicians who specialize in certain areas. Certainly minor surgery, as well as the injection of drugs, has always been solely the direct and active responsibility of the physician, but now it also appears to be becoming, under remote supervision, the task of a physician's assistant,+ a newcomer to civilian medicine in the United States, although he has been recognized for years in the military services as a medical corpsman and in the Soviet Union as a Feldscher.[1] Because medical technicians do not always work under the direct supervision of a physician, it raises *de novo* the education and function of the optometrists in relation to those in the other health professions.

Reason for This Study

Our initial consideration of these problems was prompted by the development of computer-assisted optometry[2-5] by which the optometrist could delegate some of his activities to a computer. The rationale is that the computer does what it can do as well or better than a human being; the optometrist does what the computer cannot do (for the foreseeable future). The cost of remuneration for people doubles about every 20 years where the cost of computers and peripheral equipment has been decreasing exponentially dropping to half every computer generation of about three years.[6] There is little doubt that these curves will ultimately cross and the computer will do whatever it is capable of doing less expensively. Even though exact costs are not known at this writing, the cost of certain optometric services can ultimately be reduced, while increasing the availability of the services as well as the remuneration of the practitioner. It was originally assumed that if called upon, optometrists could handle no more than 10 or 15% more patients as indicated in a recent survey.[7] Our goal was simply to find how much time optometrists spend in various phases of their office work in order to determine how much their patient load could be increased by delegation.

Although there appears to be adequate ophthalmic serivces at present, it seems that increased efficiency will be

necessary for several reasons. First, there appear to be pockets of disadvantaged populations who do not have easy access to eye examinations because of cultural or economic considerations. If these barriers were to be dropped, an increased load would fall upon optometrists. Secondly, a number of health bills have been introduced into Congress which would extend health care for virtually everyone; some include refractions. This too, would increase the patient load. Third, if a rational division is made to allow ophthalmologists to work primarily at their high level of surgical and medical training in addition to general ophthalmology (and help decrease the physician shortage) while permitting optometrists to do more of what they are thoroughly trained for (especially eye examination including ophthalmic refraction), an increased case load would be the result.

We found that not only could most of the optometrist's current work load be delegated to both human assistants and to computer assistants, but also, to our surprise in some instances, the optometrist was far from working near full capacity even when he was working without assistants.

An Introduction to the Study

Eighteen optometrists were selected from a list of those practicing in the San Francisco Bay Area, primarily because they were accessible and because they were part of the large majority of optometrists who appear to practice ethically as opposed to commercially. They were asked if they would agree to be timed by one of us (Dr. Ng) for one morning, preferably a busier one. Of the 18, 13 agreed to be timed. Five refused, stating that either their patients would not appreciate a third person observing the examination or confessed that having someone critically timing them would make them nervous.

A stopwatch was used to time each defined activity to a fraction of a second. Each delivery, refraction, adjustment, progress check, and consultation performed by the optometrist was accurately timed. Telephone calls, referral calls, administrative duties, calls to laboratories, advising the receptionist or assistant were also timed in order to get an overall picture of an optometrist's day. On the average, it appears that the sample morning was a typical one in these practices.

Most of the optometrists had a receptionist whose duties were to schedule appointments and keep records. Four of them had aides or assistants who helped take the case history, visual fields, and helped the patient select new frames. A few receptionists also took care of some, if not all, of the spectacle adjustment and repair problems of patients who dropped into the office while the optometrist was busy. None of the activity of the assistants was timed or recorded.

While new methods of delivery of eye care may be impending which could change the methods and patterns of practice, they have not yet significantly arrived. The solo practitioner is still ubiquitous and he alone was observed. The results could also be adapted for new forms of practice once they were specified.

TABLE 1. – No. Patients Seen by Optometrists on Single Morning

Optometrist	Year of Graduation	Year started Independent Practice	All Patients	All Refraction Patients	New Refraction Patients	Contact Lens Patients	Progress Checks	Frame Adjustments	Dispensing
1	1951	1955	7	2	1	1	1	3	0
2	1943	1962	10	4	1	0	0	2	4
3	1948	1951	9	4	3	0	0	3	2
4	1953	1953	3	1	0	1	0	0	0
5	1963	1969	0	0	0	0	0	0	0
6	1939	1941	5	2	0	0	0	0	3
7	1948	1960	10	4	1	0	1	3	2
8	1943	1943	6	3	2	0	0	1	2
9	1948	1953	5	2	1	0	0	2	1
10	1940	1941	4	2	2	0	0	1	2
11	1952	1952	10	4	1	3	0	1	2
12	1951	1954	3	2	1	0	0	1	0
13	1941	1949	7	4	2	0	1	0	2
Totals			78	34	15	5	3	17	21
Averages			6.00	2.62	1.54			1.31	1.62

Zeros are included in averages in only this table.
The average optometrist had 2.62 refractions although range was from 4 to 0 for the newest practitioner.

Results

Table I illustrates the number of patients seen by each optometrist during the half day of observation. The total patient load is divided into categories depending upon the purpose of the visits.

Table 2 shows the time in minutes of the various tests administered by the optometrist during the course of routine eye examination and refraction. The sum of all test averages was determined to give the average time required to perform a general eye examination and refraction, sometimes called a visual analysis. Some optometrists took the case history simultaneously while obtaining other data. When more than one event was happening simultaneously, primarily with the case history, each was timed separately as if performed sequentially. The sum time of the individual tests and activities may as a consequence be somewhat longer than the actual total time, but the differences are small.

Optometrist number 1 was not timed while giving advice to his patients apparently because he sandwiched it in during other activities when it was not clocked. Incidently, he was also the fastest performer in ophthalmoscopy and retinoscopy. Optometrist number 3 and 12 each had an assistant take the case history and help the patient in frame selection. Numbers 1 and 13 had the assistant only take care of frame selection. Visual fields were performed on only two patients by two optometrists, number 7 did a Harrington-Flocks visual field screening test and number 6 a one-meter tangent screen examination. Tonometry was performed by the optometrist on all patients over 35 years.

It should be noted that where a test was not taken and the time is zero, this value is not entered into the average. Thus the average represents the time generally taken for a test when it was given by the optometrist.

Table 3 shows the dispensing times. Except for optometrist number 5, who had no patients that morning, a zero may indicate that the task was done at a time when he was not being clocked, for example in the afternoon or on another day. Optometrist number 1, for example, checks and writes all his orders for the day the first thing in the morning, which was timed at 5.08 and 12.10 minutes. Others may have written and checked them for the day at the end of the day and were clocked at zero time for these activities in the morning. The corresponding averages therefore may give an overestimation of the time. Table 4 lists contact lens progress check time.

Discussion of Data

The number of patients seen per half day ranged from zero to ten. It was a source of surprise to us how frequently patients did not appear for their appointments, some cancelling the same morning and others "not showing" without warning.

Repeat patients (those who had

Table 2. – Times in Minutes for Various Parts of Optometric Examination

Optometrist	External Examination	Case History	Set up Equipment	Opthal-moscopy	Retinoscopy	Subjective	Muscle Balance	Visual Acuities	Near Tests	Bifocal Adds	Keratometry	Tonometry	Frame Selection	Check Old Glasses	Advice
1	0.00	2.38	0.00	0.49	0.49	3.95	0.65	1.39	1.96	0.00	0.00	0.00	3.13	1.02	0.00
2	0.52	3.23	3.13	2.36	1.75	6.31	1.99	1.03	1.87	1.58	0.00	0.00	5.64	2.09	6.35
3	0.63	4.52	2.86	2.88	1.43	5.07	1.93	2.09	1.60	2.97	0.00	0.98	0.00	0.00	5.05
4	0.66	3.68	0.00	2.50	2.75	8.30	2.35	0.63	3.52	0.00	3.07	0.00	0.00	1.50	13.10
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.28	0.70	0.00	2.51	3.50	2.18	1.10	0.80	1.53	2.15	0.00	4.74	0.00	0.00	2.14
7	1.41	2.16	0.00	2.21	1.89	6.49	3.29	1.60	1.44	5.02	1.99	5.17	9.56	0.00	0.48
8	0.16	5.49	1.25	4.42	1.93	7.19	2.49	2.07	4.07	1.14	0.00	2.71	8.18	1.50	5.78
9	0.87	3.00	0.00	1.04	1.83	3.79	0.66	0.00	2.83	0.74	0.00	3.67	0.00	0.00	6.12
10	0.15	1.79	1.05	0.98	1.07	9.18	1.62	0.79	9.95	1.80	0.00	2.58	6.28	0.00	2.76
11	0.23	2.02	1.33	1.56	1.32	4.82	1.16	1.88	1.67	1.40	0.00	2.34	9.29	0.00	3.15
12	0.66	3.56	0.00	1.09	3.71	10.50	2.44	2.75	4.92	4.13	0.00	0.00	11.00	0.00	7.83
13	1.25	3.79	1.85	2.19	1.05	8.15	1.02	1.86	1.32	2.66	0.00	1.47	2.75	0.00	7.17
Averages	**0.62**	**3.03**	**1.91**	**2.02**	**1.89**	**6.33**	**1.73**	**1.48**	**2.29**	**2.36**	**2.53**	**2.96**	**6.90**	**1.53**	**5.45**
Total	**43.03 minutes**														
										14.19					

Zeros not averaged so that times would represent an average for the test if performed by the optometrist. Some were delegated to the office assistant who was not timed.

been previously examined and refracted in that office) ranged from zero to three per morning. The rest of the patient load included deliveries, contact lens progress checks, adjustments and repairs and regular progress checks.

In an eye examination, the average optometrist of our study took a case history, visual acuities, external eye examination, vergences, phorias, ophthalmoscopy, retinoscopy, subjective examination and near tests. In addition to these specific activities, much time was spent with the patient in giving advice and explaining his ocular condition to him. While tonometry was performed by the optometrists on all patients over 35 years, visual fields were not routinely plotted. The average complete examination took 43 minutes of the allotted hour to complete, including the selection of a new frame by the patient. The single most time-consuming activities are the basic subjective refraction at 6.3 minutes (14.2 minutes with acuities, muscle balance, near tests and bifocal adds), frame selection at 6.9 minutes, and the time taken to advise the patient of his problem and treatment at 5.5 minutes.

Aside from examining patients, the bulk of the remaining time spent was with frame adjustments and deliveries, averaging about four and seven minutes respectively.

Delegation of Tests

What can an optometrist delegate? Clearly, it has been customary and recommended by practice management authorities to delegate appointment making, record keeping, bookkeeping, reception of the patients, and at times and in part, frame selection.[8] There is little argument or question about the delegation of these activities.

Our departure from current practice is in assuming the maximum use of delegation without a decrease in the quality of service. Possible consequences of pathological processes are generally of the greatest concern and the early manifestations of these processes often take the greatest skill to detect by direct ophthalmoscopic and biomicroscopic observations. These are not currently automatable and are reserved solely for the doctor.

Delegation, of course, depends on the role and skills of the delegatee and what is being delegated. For example, the whole examination can be delegated to another optometrist but this would result in no saving. It can be assumed for our purpose here that the delegatee is an alert, well-motivated, and reasonably bright high school graduate who has been at least as well-trained in the specific delegated duties, as is the medical technician or nurse.

A formal proposal has been made for several grades of optometric assistants with different degrees of training: the Optometric Assistant with less than two years of apprenticeship, the Optometric Technician with a two-year vocational course of study and the Optometric Technologist having a four-year college degree in optometry.[9]

There are currently four different junior or community college programs offering a two-year course for optometric assistants which give training in the optometric field and are not limited to receptionist training.[10] A textbook is now available for these assistants.[11] No distinction will be made here between the different types of assistants.

Alternatively, a computer system can be used as delegatee for some of

Table 3. – Dispensing Times Performed by Optometrist

Optometrist	Adjustments	Deliveries	Write Orders	Check Orders
1	14.12	0.00	5.08	12.10
2	4.54	14.90	4.54	0.00
3	3.22	7.78	0.00	0.00
4	6.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.72	0.00	0.00
7	4.96	12.45	0.00	0.00
8	8.27	5.34	0.00	0.00
9	2.44	6.01	7.77	0.00
10	3.27	5.90	0.00	0.00
11	4.18	3.88	0.00	15.47
12	0.85	0.00	0.00	0.00
13	0.00	5.92	0.00	0.00
Averages	**4.17**	**7.00**	**5.81**	**13.77**

Total Average Time: 30.75 Minutes

Table 4. – Contact Lens Progress Checks

Optometrist	Progress Checks
1	0.00
2	0.00
3	0.00
4	11.27
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00
11	9.58
12	0.00
13	0.00
13	**Avg: 10.40 minutes**

Zeros are not included in the averages

the tests and other activities in which have been programmed the combined and balanced training and experience of experts in the field of ophthalmic refraction and care. Further, some aspects of optometrists' functions, such as ophthalmoscopy or tonometry, have too complex an input or output for computers to handle successfully at present. Table 5 shows a breakdown of the various tests and activities that must be done by an optometrist and those which can be done by a human assistant or a computer assistant. It is constructed so that everything that can at present be done by a computer is, and everything that cannot be done by a computer and can be done by a human assistant is assigned to him. The optometrist is reserved for those activities which he cannot delegate but must do himself because of his special training and responsibility.

Because the computer cannot do it, and because of the high degree of training required, the optometrist must perform the external eye and the ophthalmoscopic examination as well as biomicroscopy. A start towards automated ophthalmoscopy has been made but it will require a long development before being perfected.[12] The computer could perform retinoscopy, but the extra instrumentation at this time may not be worth the additional expense. In addition, it is the optometrist's responsibility to make a final review and final discussion of the entire procedure and all final decisions. In the absence of any firm data we have estimated the final review and discussion time after maximum delegation to be five minutes. Human assistants can set up the equipment, perform keratometry and tonometry, check the old glasses, make adjustment and deliveries, and check orders. This comes to 33.9 minutes. The computer can take the case history, perform the subjective examination including visual acuity, muscle balance, near tests, bifocal adds, as well as styling frame selection, advice which does not require trils of the spectacles, and write the order, subject of course to the final review of the optometrist. This would take 33.8 minutes if it were done by the optometrist and it saves him that much time. The computer would take longer than a human being but this is not a debit on the optometrist's time.

Table 5. – Delegation of Activities to Computer and Human Assistants

Time Block (min)	Test	Optometrist Time (min)	Human Assistant Time (min)	Computer Assistant Time Freed (min)
	external eye	.6		
	case history			3.0*
	set up equipment		1.9	
	ophthalmoscopy	2.0		
	retinoscopy	1.9		
	subjective			6.4
	muscle balance			1.5
41.4	near tests			2.3
	bifocal adds			2.4
	keratometry		2.5	
	tonometry		3.0	
	styling frame selection			6.9*
	check old glasses		1.5	
	advice			5.5*
	adjustments		4.2	
	deliveries		7.0	
30.8	write orders			5.8*
	check orders		13.8	
5.00	final check and discussion	5.0		
77.2		9.5	33.9	33.8

*Without a computer system, these tasks could be performed by human assistants. This adds up to 55.1 minutes for the human assistant's time and 22.1 minutes for that of the optometrist.

If these figures are valid, the optometrist with adequate human and computer assistance could take care of as many as six patients per hour instead of one since he requires only ten minutes per patient rather than an hour. This assumes no change in the quality of service. Fewer patients could be examined per hour with an increase in quality of service. It would seem desirable to increase the quality by including routine biomicroscopy, eye and fundus photography and visual fields as well as spending more time on ophthalmoscopy.

Conclusions

Computer-machines are bound to perform an increasing share of our work. Aldous Huxley pictured a "Brave New World" in which the Alphas were the intellectuals, the Betas the subintellectuals, graded through the Gammas, Deltas and finally the Epsilons, the small, simian-like semi-morons who did the most menial work.[13] Imaginative as it is, the picture is turning out to be clearly wrong. We are, or believe we are, all Alphas. The work of the Betas is being increasingly delegated to the computer and down the gradient to that of the Epsilons which has been given to the machine. The Alphas of our society are those who, in the broad sense, control the computers and machines. He who tries to compete with the computer or machine is fighting a losing war.

Our time study results probably apply equally to physicians who refract as well as to optometrists if two assumptions are made. First, that eye physicians give as complete and thorough a refraction as indicated in Table 2. It also implies that they do, as part of the service of their office, the delivery and adjustments of glasses, which is said to be 14.6% true.[14] The dispensing times can be subtracted where they are not applicable.

As mentioned earlier, our optometric sample is not entirely representative in that it does not include that highly conspicuous minority who appear to practice more commercially than professionally. Incidentally, the services of an ophthalmologist and optician for an eye examination and glasses are claimed to cost from one fifth to one half more than comparable services by an optometrist.[15]

These results also point to another aspect of the ophthalmic field. There are many specialites in it that cannot currently be significantly computer-assisted. These are contact lenses (aside from record keeping and order-

ing), strabismus diagnosis, low vision aids, and perhaps aniseikonia. However, other aspects can be readily computerized, such as visual fields, orthoptics, and patient education.

The maximum use of delegation to both computer assistant and to human assistants points to a likely future trend. The optometrist will spend an increasing percentage of his time in those fields which cannot be readily assisted, although to maintain control of the quality of the procedure he must continue to be knowledgeable and skillful in all aspects of the examination including those fields which can be automated or assisted. It also indicates that if he is going to continue his relative role in visual care *vis-a-vis* ophthalmology (also computer assisted) he will have to work towards performing a greater number of eye examinations. Exact figures are not available but currently the optometrist appears to perform slightly more than half[16] or 62.5%[14] although he is several times in number. However, he dispenses the eyewear also. As pointed out in the California State Plan for Health,[17] "a substantial volume of eye refractions are being performed by ophthalmologists which might be performed by optometrists. This displacement of optometrists by ophthalmologists in the provision of eye refractions is unfortunate, since it may result in higher prices for such services." The Plan recommends a review of the relative roles of the optometrist versus the ophthalmologist which could result in more effective and efficient utilization of the skills of each.

In sum, the conclusion appears inescapable that unless the demand for refractions, contact lenses, and other optometric services increases to fill the greater capacity brought about by the expected greater use of assistance, both human and computer, in both optometry and ophthalmology, optometrists may be under pressure to enlarge the scope of optometric practice. If such a move to enlarge the area of competence of optometry is considered, it would be foresighted to plan now an expanded education in these fields for optometrists. Expansion of curriculum need not necessarily be in extended time but in the organization of courses, since it now takes as long to earn a Doctor of Optometry degree as it does for some courses leading to the Doctor of Medicine in this country (although still three years less than to be a board-certified ophthalmologist). In terms of public health a special attraction of such a course of action would be the release of the training of physicians from the field of ophthalmology to those areas where the greatest shortages exist such as pediatrics and family physician.[18]

Veterinarians were once challenged by a machine with devastating effects on their numbers. The machine was the developing automobile which at the turn of the century economically decimated the transport horse population, reducing the need for "horse doctors". Since that time, veterinary medicine has had a renaissance by expanding its services in other directions such as food animal production, public preventive medicine programs and companion animals.[19] Planning the use of computer and human assistants and the degree and the directions of adaptation to computers in optometry might avoid dislocations, even transient ones, and provide broader, less expensive and better visual care for the public.

We thank the 13 anonymous optometrists who cooperated with this project in the interest of the profession. We also acknowledge valuable suggestions from Leonard Osias, O.D. The conclusions are our own.

*Many computer interview and multiphasic systems are available. One of the first and biggest is Searle Medidata, Inc., 140 Fourth Ave., Waltham, Mass. 02154. Others include Comprehensive Health Testing Laboratories, 350 Parnassus Avenue, San Francisco, California 94117 and Predictive Systems, Inc., Palo Alto, California 94304.

+Physicians' Assistants Bill. Article 18 of Chapter 5, Division 2 of the California Business and Professions Code (Assembly Bill No. 2109, approved September 17, 1970). The above bill makes no mention of direct supervision as does Article 3 on Mobile Intensive Care Paramedics for the administration of parenteral medications.

References

1. Carlson DL, et al: The physician's assistant: an annotated bibliography. Institute for Interdisciplinary Studies, American Rehabilitation Foundation, Minneapolis, Minn. 55403, Dec. 1970.

2. Marg E, G Liberman, and ERFW Crossman: Toward computer assisted optometry. *Optom Weekly*, 60:17-20, 1969

3. Crossman ERFW, PJ Goodeve and E Marg: A computer-based automatic method for determining visual acuity. *Am J Optom Arch Am Acad Optom* 47:344-355, 1970

4. Marg E, et al: A prototype automated, branching case-history taker for eye examination. *Am J Optom Arch Am Acad Optom* 49:105-112, 1972.

5. Crossman ERFW, PJ Nargavala and E Marg: An information-theoretic analysis of clinical refraction. *Am J Optom Arch Am Acad Optom* 48:391-406, 1971

6. Gerard, RW: Computer-assisted learning: introduction and general considerations. *Proc Nat Acad Sci* 63:573-603, 1969

7. Peters, HB and RN Kleinstein: The availability of optometric manpower in California in 1968-2000. *Am J Optom Arch Am Acad Optom* 46:283-293, 1969

8. Elmstrom GP: *Optometric Practice Management*, Chilton, Philadelphia and New York, 1963. *Practice Management Manual*, Laurence Leiter and Company, American Optometric Association, 1965.

9. Visual Care for the 1970's: A Plan for the Development of an Optometric Paraprofessional Training Program. Vertical Systems Co., P.O. Box 5731, St. Louis, Mo. 63121. Feb. 1971.

10. Loring PJ: Optometric technicians and physician's assistants — new developments in health care manpower. *J Amer Optom Assn* 42:464-469, 1971

11. Bates, SS: Fundamentals for the Optometric Assistant, Chilton, Philadelphia, 1970

12. Dallow RL: Television Ophthalmoscopy. C.C. Thomas, Springfield, Ill., 1970

13. Huxley A: Brave New World, Harper and Brothers, 1939, reprinted Bantam Books, New York, 1962

14. Delafield LL: Copyright Report for Smith, Klein and French, Dec. 1, 1968.

15. Hirsch, MJ and Wick, WE: The Optometric Profession, Chilton, Philadelphia, 1968. p. 309

16. Characteristics of Persons with Corrective Lenses, National Center for Health Statistics PHS Publication 1000, Series 10 number 53, HEW, Washington D.C., 1969

17. Farag, SA, ed.: California State Plan for Health, Preliminary copy dated April 29, 1971, State of California Department of Public Health, Berkeley, Calif. 94704.

18. Richardson EL: Myth and reality: problems of health care. *New York Times*, 37M, April 2, 1971

19. Smithcors JF: *American Veterinary Profession: Its Background and Development.* Chapter 14. Iowa State University Press, Ames, 1963