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TALK ABOUT COMPUTERS IN PRACTICE

The Portable Practice

Attention was perhaps first drawn to the potential of the computer in optometric practice a quarter of a century ago in the era of the Beatles (Marg etal, 1969), and it has taken that long for the standard technology to become affordable, convenient and advantageous (French, 1993a) with the most interesting developments occurring in the last ten years, since the introduction of the IBM Personal Computer. The next ten years is likely to be even more fascinating!

Figure 2: Portable optometry in its most elementary form - a typical Notebook PC, here a CIC Computers 486SLC Notebook with VGA screen.

History

Grossman etal (1970) pointed to the use of CRT displays and demonstrated how computer control could be used to automatically measure acuity, hi 1971, one of us devised software to draw variable size symbols on CRT displays and vised this to produce alphabetic sight test acuity charts in various fonts. The symbols used, were composed of lines, which the computer rotated, enlarged and drew on extremely high resolution screens. Unfortunately, it was not practical to put a patient in front of these displays as the mainframe computer was slow and remote. Instead, the output was recorded off-line on 35mm film for showing to subjects later. This was used in laboratory work (eg French etal, 1973) to study matters such as comparative letter legibility, and similar technology was employed to produce random-dot stereograms in 1974 for Tomlinson and Wood (1976), following on from the work of Julesz (1971). Twenty years later photographic negatives are still used by today's optometric chart projectors.

Although the potential was already there back in the early 1970s, the technology of the day meant that mobility was not. One could hardly drag a mainframe computer around; remote access via telephone lines was not really practical; and the mini computers then available lacked power and speed.

It was perhaps not until the introduction of the Intel 8088 chip and the IBM PC back in 1983 *(launched August 1981 in the USA)* and the subsequent arrival of PC compatibles that it seemed to one of us that a sophisticated on-line clinical tool would soon become practical at a reasonable price. Returning in 1986 to computer-generated charts, French devised a PC programme with standard fonts tor optometry students and then used this to assess the potential in clinical trials in a hospital (French etal, 1990; MacNamara etal 1991). Some people had already begun to use early micros like the old BBC and Apple computers to produce very simple testing devices based on limited symbol sets such as tumbling E's (eg Timberlake etal, 1980), while others had adopted a 'hardware' approach - eg the InnoMed Terry Vision Analyzer (Terry etal, 1989) and Mentor Video Acuity Tester - depending upon dedicated logic circuits and electronics, rather than software and standard consumer computers.

Improvements in computer graphics also offered the opportunity of a general field-testing device without the need to dedicate a primitive computer to a single task and we carried out trials from 1985

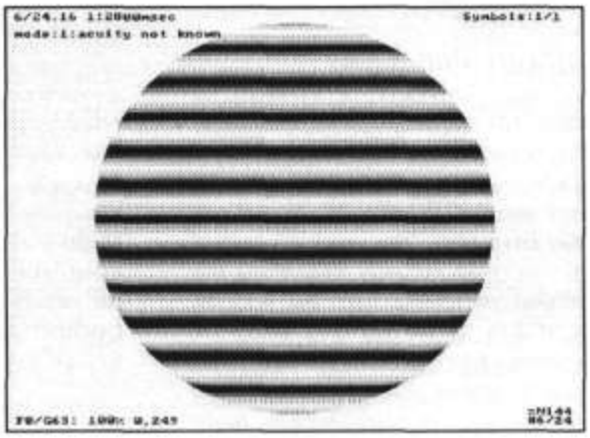

Figure 1: UMIST Eye System's sine wave, contrast sensitivity target.

Acuity tests incorporated in the **UMIST Eye System** use Bailey-Lovie style 4x5 letter set DEFHNPRUVZ; Sloan style 5x5 CDHKNORSVZ or numeric 0123456789; 5x5 HOTV, HOTVX, HOTVXLA, HOTVXALCU and HOTVXA = ± +; lower-case aceimnoprstu; pictograms for children; Ffooks style symbols; tumbling E's; & Llandolt-style C's; square-wave gratings and vernier.

Passive and interactive acuity testing is accommodated using single-character, single-line, double-line and multiple-line presentations with variable contrast. Identification and detection stereograms, and sine-wave and letter/digit/symbol contrast sensitivity are also incorporated.

Optometric display tests include an astigmatic fan, cross-cylinder circles and disks, duochrome, OXO-style displays, phoria test, random vehicle number plates, Sm-eye-ly face and a Worth-style figure.

A user-configurable City-style 18-bit colour vision test is provided.

Three sets of field-screening procedures are provided - single static, multiple static and kinetic with full parametric control (position, size, timing and luminance) of stimuli and their configuration.

Screens may be fully calibrated, several acuity scales are included and most results can be automatically stored in the integral database.

(French and Wood, 1989). Colour vision testing using CRTs began in the middle and late 1980s (eg Arden etal, 1988).

To us the hardware approach appeared to be addressing something of a blind alley, particularly with acuity. Such systems have often been extremely expensive *(upwards of several thousand pounds),* sometimes fairly crude *(low resolution)* and always very limited - incapable of doing word-processing and accounting, and committed to a single task. Despite this, such "dinosaurs" are apparently still being produced. It will be remembered that in the early days of word-processing specialised computers were devised, dedicated solely to that chore.

Modern PC

It was with the arrival of VGA graphics for the 80286 PC AT (1987) that computer speed and graphics potential combined in a standard computer form to allow software to provide an instrument superior to that contributed by customary optometric technology; with the more recent one megabyte, 1024x768-resolution video cards permitting simultaneous high resolution and multiple colours, enabling sine wave contrast sensitivity testing (Figure 1).

It is only in the last couple of years that the price of particularly powerful versions of these standard machines has really become attractive. With these considerations in mind, a general purpose optometric programme, the UMIST Eye System, was launched commercially after trials in practice in 1991 and 1992 (French, 1993a; French, 1993b; Hopkins and French-Teeling, 1993; see Box). The PC that makes such software very effective is more than 50 times more powerful than the original IBM model and even ignoring for the effect of inflation is more than five times cheaper, hi ten years the PC has come a very long way.

The PC is now the machine of choice for the computer games aficionado, the musician and even the domestic user. With the largest range of software of any type of computer, small businesses are using it regularly for accounts, records, desktop publishing and presentation graphics. And these represent just the tip of the iceberg. The same PC can also be expanded and used as hi-fi, radio, TV, answerphone, video-recorder, CD-player, fax machine and a lot, lot more. These developments are reflected not only in the huge growth of PC computer magazines but also in far more frequent advertising in national and local newspapers. Now, you can even rent a PC from the same people who normally rent you TVs and videos. The ideal machine, an 80486 introduced in 1990, can be obtained new for just £800 while bargain basement 80286s can be bought for a couple of hundred pounds. Although still pricey, more portable, basic versions of true Notebook PCs can be bought for upwards of £600.

Such economy will become even more striking as the cost of PC computing continues to decline. Every year without exception, computers become substantially more powerful and inexpensive. Today's PC is about half as powerful as a mainframe processor, but in another decade will be 500 times more powerful (Schofield, 1993).

Software Philosophy

Today, the equivalent of upwards of £7,000 of specialised optometric equipment can be provided for the cost of a wordprocessor - just £250 for the software plus the cost of a PC *(free if you already have one).* The resulting system will not only do virtually everything the specialised equipment can, but will do much of it far better and do a whole lot more optometric-wise that the dedicated equipment cannot. This combination of PC and software is more flexible, more intelligent, more powerful - *and also more portable - if a Notebook PC is used.* It is not an attempt at stinting on optometric equipment!

The UES represents a whole philosophy of approach. The computer set-up is open-ended, encouraging the addition of other optometric and visually-related software.

Portability

Portability brings with it a new dimension - the mobile practice. The practitioner is no longer tied to their refraction room and there is less need to short-change a patient while carrying out home visits.

Ten years ago there were portable microcomputers but they lacked power. There were home computers like the Sinclair Spectrum and PC-compatibles like the Osborne. The latter were often described as "luggable" to indicate their failings. Over the years portable PCs have become smaller. Terms used to describe them have progressed from "portable" to "compact", "lap-top", "palm-top", "pocket", "notebook" and "sub-notebook". There has always been a higher price to be paid for smaller size. Portable PCs still sell in comparatively modest numbers so there is not the same cost-savings that can be accomplished with the mass-sales of the machines with standard casings, although this is clearly a major growth area and the market is changing rapidly. It is, of course, the mass-sale of the PC-compatible which has generated the largest software base of any computer that, in turn, has further increased its popularity.

For the optometrist it needs to be said that there are still shortcomings to be adapted to in portable PCs. The flat screens today used by all genuine portable PCs remain inferior to the standard CRT display. Also if one wants to go for a top quality colour flat screen then the price rises by a thousand pounds. Costs can be minimised and optometric performance maximised by plugging in an orthodox VGA monitor. The problem is of course that this reduces portability and introduces the need for a handy power point. *(Maybe also an extension cable and round-to-square pin adaptor but hopefully not a portable power generator!)* A typical true Notebook PC (Figure 2) weighs a mere couple of kilograms and runs on integral batteries for several hours, but the average 14" monitor might add a further 12 kilograms to your luggage and need mams power.

Figure 3: Young patient viewing large version of Sm-eye-ly via the mirror. Chart projector located below monitor is for back-up but these days your computer might be expected to be as reliable as your conventional chart's light bulb.

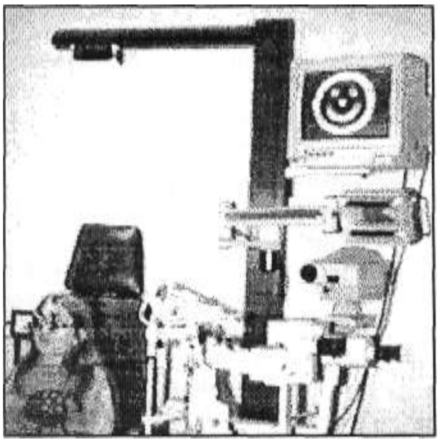

Figure 4: The UES colour vision test being carried out by the patient, themself. Here, this computer monitor and keyboard are on a wall-mounted swivel arm which has been swung from its usual position beside the practitioner,

UMIST Eye System

Since its launch, the UMIST Eye System lias continued to develop. It was designed for use in clinical practice, vision research and education - anywhere that a thorough test of vision is needed.

In its simplest mode the PC is directly viewed at a variable distance to suit conditions - as it would be on a home visit. Adding a mirror enables the system to be used conventionally in a short room maintaining the standard 6 metres, replacing a chart projector or conventional chart. The computer monitor is then either stood on a shelf attached to the wall behind the patient or placed on an optometric column (see Figure" 3). hi tliis position the monitor can still be viewed directly when needed - as with wheelchair patients.

Depending upon the monitor arrangement adopted, the patient can be moved towards the screen for close-up work or the monitor swung around to face them. Alternatively, a second optional monitor can be brought into play. This might be to carry out colour vision testing (see Figure 4), field testing with a head rest and so on.

When the computer is not being used by the patient with the UES, the same system can be employed for reminders, word-processing or other work. If you wish, the monitor and keyboard can be moved or additional monitors and keyboards can be utilised.

If the PC is a 386 or 486 with sufficient memory then the practitioner can use Microsoft Windows to have several applications available at once. The PC might be running a TV programme or a music CD along with a patient database and the UES. For example, by pressing a single button or key the practitioner can toggle instantly between screens showing current appointments, a chosen patient's clinical details, phone services and the part of the UMIST Eye System currently being used.

Flexibility is the keyword with the hardware as well as the software, the combinations and permutations being endless (see Figure 5). The local PC can be a regular desktop model stood on the floor in the corner of the consulting room or a portable Notebook ready to be whisked off on a domiciliary visit or home for some evening work - *for tasks ranging from accounts through embroidery to the children's homework.* It can also be a disk-less machine, networked to a central file-server.

The practitioner can easily have immediate on-line access to the practice's databases with full patient particulars and appointment details along with other PC facilities from fax to spreadsheets. Today the practitioner also has a right to expect that any modern piece of optometric hardware will come with software to enable its findings to be simultaneous available on screen - whether it be on-line via a parallel or serial interface or off-line via a disk, "smartcard" or other storage device.

The keyboard used by the operator can be the PC's or a remote infra-red programmable keypad, identical to that used by today's video recorder and other domestic electronic appliances. These days you can even buy a watch with a built-in remote control and this could be used alongside the conventional keyboard. *(How many years before the PC itself will be* *inside* *the, watch ? Tlie smallest PC today is a box 210x35xl25mm - unfortunately more expensive than a Notebook, perhaps primarily designed to fit inside equipment.)* But personally, we still prefer the convenience of the conventional QWERTY keyboard despite PC manufacturers' research which shows the keyboard as a user "turn-off". Its layout may be economically unsound but for those who have been brought up to use a typewriter or taught computing at school the QWERTY keyboard is natural requiring no further practice or training.

The conventional keyboard and the various infra-reds can be further enhanced. With thousands of screens possible with the UES, single keys cannot be assigned to each and every one although they require just a few sequential key-presses. Those users that feel that even this is not close enough can easily programme key commands so that all the screens they use the most often are "a single key-press away", giving them instant access ui rapid succession to a personalised system of acuity charts, cross-cylinder displays, colour vision tests and so on.

Voice control of computers is a further option enabling hands-free operation of virtually all computer operations. The user programmes the commands appropriate to his or her needs. Commands can be primitive as, for example, in "Up", "Down", "Left", "Select", basic as in "Alpha", "Bravo", "Charlie" for "A", "B", "C", or advanced.

hi advanced mode, for example, calls of "Lowercase", "Double", and "Twenty-four" in quick succession will, with the UES, bring up the 6/24 and 6/18 rows of lowercase letters. The command "Five-per-line" could be programmed to show five symbols per line while a call of "Three-per-line" would restrict displays to just three. "Low contrast" and the screen contrast would be reduced to (say) ten per cent. "Dynamic Fields" might initiate a field screening with moving targets while "Colour" would bring up the colour vision test. "Record" would place you back in your favourite database with your patient's record, ready to

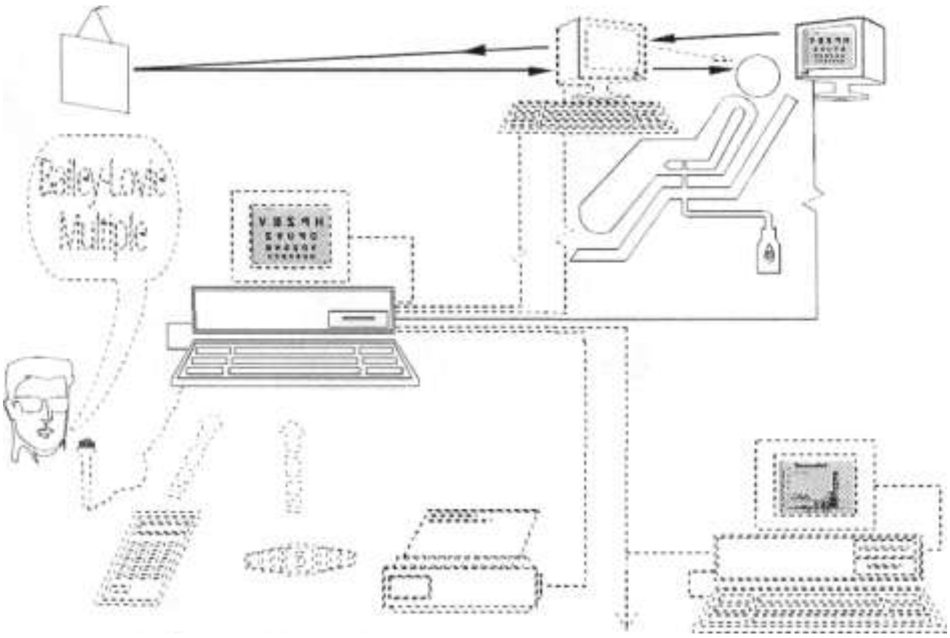

Figure 5: Schematic of possible UES computer setups. Dotted lines indicate possible options - remote infra-red keypad, remote infra-red watch, speech recognition input, additional keyboard, extra monitors, printer and connection to network with further PC computers. For maximum portability the UES PC would need to be a Notebook model.

record your findings.

For voice control to be successful, it is important to note that you require good diction, you need to take a careful, systematic approach to the problem and you need to be very patient - particularly while you "train" your computer. It is perhaps a task for the computer enthusiast rather than computer phobe! But for a modest outlay you ought to end up with what one can perhaps begin to describe as an intelligent sight testing system - where the important decisions are still under the control of the eye care professional.

But be careful when you cough, and don't forget to remove your headset when you go the toilet or the wire attaching it to the computer is there to bring you down to earth. We are on the lookout for a cheap cord-less microphone!

Hardly any of such flexibility is available with a rigid piece of hardware equipment, but with a standard PC, the right software and the odd add-on the possibilities are endless. Your standard keyboard, your remote infra-red keypad and your voice-control unit can be simultaneously available enabling you to use whichever input medium is most appropriate.

Patient Response

Trevor Hopkins lias suggested (1993) that patients tend to take a rather blasé attitude to computer-assisted refraction. On the contrary, in the experience of one of us there is a sizeable proportion of the population who respond very positively, intuitively aware that they are experiencing something innovative and more advanced than usual.

There are a number of circumstances where the system makes a particularly noticeable contribution. Whenever it is necessary to monitor a patient's progress over a period of time it is important to have a method of testing acuity where reliability can be increased and validity guaranteed. The sky is the limit with the former with the potential for showing over 20 symbols at each size, while true randomness means that the subject can never learn a chart so each re-test is truly independent.

A recent case concerned a commercial pilot whose occupation obviously requires a good visual performance. The gentleman is myopic in one eye and aphakic in the other. Being R-8.00 L+8.00, the only way he can meet standards is to wear contact lenses. Recently he suffered a central retinal vein thrombosis and, although his VA has returned to 6/6, the CAA now insist on monitoring his acuities etc every 6 months. He is reassured when he comes for checkups just before his medicals that he can be supplied with many different 6/6 lines.

Colour vision testing is particularly rapid permitting routine use. Randomisation, once again, permits a quick, fresh re-test in the case of any doubts. Recently the UES test picked up a young female tritanomolous patient. Having confirmed the result with a rapid parallel-form retest, the result was corroborated by testing with the conventional surface colour test, which gave identical results. Conversation with the patient's mother confirmed a family history of what she referred to as "blue colour defect" in female members of the family.

As has already been mentioned, the Notebook PC makes it now practical to take a more comprehensive range of tests on a home visit. Most notebook PCs to-date have only VGA screens limiting them to '6/5' or thereabouts which would not appear to be a serious restriction amongst the elderly. Despite this, models with the facility for 256 colour external 1024x768 and acuities down to around '6/3' began to appear slowly in the UK in the latter half of 1993.

Some Notebooks blank their integral screens when an external monitor is plugged in but the latest that maintain it are well worth looking out for. There are no PCs with integral 1024x768 flat screens at present *(other computers with this facility cost over US$20,000 today)* so simultaneously displaying images on an internal 640x480 and an external 1024x768 screen poses a problem, solved by a few Notebook PCs by showing just a portion of the display internally *(most blank the integral screen once more when there is a video conflict).*

Apart from price, the only disadvantage of a Notebook PC is the need for a docking station if you wish to add special function, *internal* cards *(remote keypad interface, modem, fax, sound, TV, CD-ROM etc),* although, despite their diminutive size, a few A4 Notebooks can still accommodate the odd card internally. PCMCIA slots are another route to expansion but at present a rather expensive one with some functions not yet catered for.

The UMIST Eye system easily adjusts to accommodate small rooms and fit in with nonstandard distances. The system certainly helps the practitioner to satisfy the BCO recommendations (1993) for home visits. The optometrist is able to provide a huge variety of tests including colour vision, fields, fixation disparity - without having to take dozens of extra bits of equipment with them.

The appearance of a new "TV" in the residents' morning room at the Bay view Retirement Home does bring with it some hazards. One old lady not being tested became particularly annoyed when she could not see the monitor's screen and walked out in a huff! Despite this, home visit patients in particular appear to appreciate the new level of professional care and thought that the UES-Notebook combination provides, with increased practitioner confidence also transferring itself to the patient.

Back in the practice the Notebook can turn to its wordprocessing role for any reports or letters required.

The Future

It is never easy to anticipate the future. Computer voice recognition and speech have already been mentioned. Voice control systems can be obtained from around £50 upwards and can be programmed with a vocabulary of a thousand words. Of course if you want a true dictation capability then this can still cost you several thousand pounds.

Computer speech is perhaps more of a gimic. Talking computers are a routine part of modern computer games but although there are possibilities with field screening where instructions could be presented orally to the patient without distracting their attention but, unlike voice control, this capability needs to be written into the software.

The patient telling the computer what they see in field screening might seem like a good idea, with a headrest that keeps the eyes still, but the need to train the computer to recognise the user's voice would appear to rule it out - at least with present technology.

Higher screen resolutions such as 1280x1024 may become more common but they might not be expected to lead to any improvements of clinical significance.

Technophobia has led domestic appliance manufacturers to leave no stone unturned in the search for user-friendly equipment. Many of us have struggled with changing the time on the cooker after losing its manual and of course video recorders are notorious. *(Even sophisticated bar code input cannot cope with revised TV schedules ami programmes that over-run.)* Today you can already purchase a voice recognition remote control to change the channel on your television. With their proper keyboards and built in screens for menu driven software computers are potentially easier to use than domestic appliances.

According to a Gallup survey at the end of 1993, one third of the UK population had personal computers at home *(half in households with children),* and just over a fifth of all women and a third of men were using a computer at home or at work. Despite this, our general impression is that computer literacy in the UK remains unimpressive. It is worth noting that 37 per cent of families nominated their children as the computer experts in the house! Amongst 16 to 24 year olds, 35 per cent use a computer at work and 44 per cent have one at home. Although these figures concern computers in general rather than PCs, the trends for the latter remain clear.

Our guess is that with regard to optometry the important developments in the future are likely to be in terms of ever faster and cheaper PCs, although 24 bit colour *(compared to 18 with the present UES)* and unproved monitors should bring with them the potential for measuring finer contrast-sensitivity thresholds. Speed and price are always likely to provide the major advantages. Colour Notebook PCs are likely to become really affordable and 1024x768 integral screens (as opposed to 640x480) may become more of a reality in the next few years.

More powerful machines will enable more intelligent and more po werful software. The optometric user will just need to change or add to their programmes as better software becomes available. And when the need is for a more dynamic machine, the old hardware can be re-cycled for less demanding tasks like accounts, practice window presentations, contact lens instruction/education and so on.

In terms of the near future, the next step is the successor to the 80486 PC, the Pentium. This became available in 1993, but compilers only just began to appear late in the year and it will be a while before developers come up with software that will enable users to take proper advantage of the new hardware's speed and power., *and also before the Pentium's price becomes affordable!*

Further Information

The UMIST Eye System for modern PCs is available from UMIST. Further details may be obtained by writing to "Chris French, VMIST Eye System, Optometry & Vision Sciences, UMIST, PO Box 88, Manchester, M60 1QD. "

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