VISUAL PERFORMANCE

OF THE HUMAN EYE

WITH SOFT HYDROPHILIC CONTACT LENSES

by

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Visual Performance of the Human Eye with Soft Hydrophilic Contact Lenses

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Summary:

The recording of visual acuity using the Snellen letter chart is only a limited measure of the visual performance of an eye wearing a refractive aid. Qualitative in addition to quantitative information is required to establish such a parameter : spatial, temporal and photometric aspects must all be incorporated into the test procedure.

The literature relating to the correction of ametropia by refractive aids was reviewed. Selected aspects of a comparison between the correction provided by spectacles and contact lenses were considered. Special attention was directed to soft hydrophilic contact lenses. Despite technological advances which have produced physiologically acceptable soft lenses, there still remain associated with this recent form of refractive aid unpredictable visual factors.

Several techniques for vision assessment were described, and previous studies of visual performance were discussed. To facilitate the investigation of visual performance in a clinical environment, a new semi-automated system was described : this utilized the presentation of broken ring test stimuli on a television screen.

The research project comprised two stages. Initial work was concerned with the validation of the television system, including the optimization of its several operational variables. The second phase involved the utilization of the system in an investigation of visual performance aspects of the first month of regular daily soft contact lens wear by experimentally-naïve subjects.

On the basis of the results of this work an 'homoeostatic' model has been proposed to represent the strategy which an observer adopts in order to optimize his visual performance with soft contact lenses.

Key Words:

soft hydrophilic contact lens - television - vision - visual acuity - visual performance

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ABBREVIATIONS AND SYMBOLS

ac	alternating current
AGT	Arden Grating Test
AM	ante meridiem (before noon)
BCOR	back central optic radius (of contact lens)
c	circa (approximately)
CCTV	closed circuit television
cd	candela
CIE	Commission Internationale d'Éclairage
cm	centimetre (10^{-2}m)
CR-39	allyl diglycol carbonate
CRT	cathode-ray tube
CSF	contrast sensitivity function
D	dioptre (unit of lens power)
dc	direct current
DC	dioptres of cylindrical lens power
df	degrees of freedom
DS	dioptres of spherical lens power
EDTA	ethylene diamine tetra-acetate
hr	hour
Hz	Hertz (cycles per second)
K_f	central corneal curvature : flattest meridian
L	luminance
LED	light-emitting diode
logMAR	logarithm of minimum angle of resolution
m	metre
MAR	minimum angle of resolution
MHz	mega-Hertz (10^6 Hz)

min	minute
min arc	minute of arc
ml	millilitre (10^{-3} litre)
mm	millimetre (10^{-3} m)
ms	millisecond (10^{-3} s)
nm	nanometre (10^{-9} m)
NS	not statistically significant
pHEMA	poly (2-hydroxyethyl methacrylate)
PM	post meridiem (after noon)
PMMA	polymethyl methacrylate
RI	refractive index
S	experimental subject
s	second
s arc	second of arc
TV	television
V	vision
VA	visual acuity
VDU	visual display unit
VER	visually evoked response
VP	visual performance
µs	micro-second (10^{-6} s)

R	registered commercial name, trade mark
^{o}C	degrees Celsius (centigrade)
Ø	overall external diameter (of contact lens)
$\sqrt{\ }$	arithmetical square root
%	per cent, percentage
#	number
p<	statistically significant]...
p>	not statistically significant]

...at probability level indicated

GLOSSARY OF TERMS

bit	'binary digit', i.e. - $\log_2 \left[\text{number of possible alternatives in an equiprobability situation}\right]$
lens	'a portion of a transparent medium bounded by two refracting surfaces'
hard lens (rigid lens)+	'a contact lens which, under normal conditions, substantially retains its form without support'
soft lens (flexible lens)+	'a contact lens made of material which, in its final form under normal conditions, readily yields to an applied force'
soft hydrophilic lens+ (hydrogel lens)	'an example of a specific type of soft lens, being one that requires a substantial quantity of water to obtain its functional form'
vision/visual acuity	vision (V) is 'the resolving power of the unaided eye', and visual acuity (VA) is 'the best resolving power of the same eye when it has been provided with its proper optical correction' - this clinical distinction is not consistently observed in the present text

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+Source: B.S. 5562 (1978a): Specifications for Contact Lenses, citing B.S. 3521 : Glossary of Terms Relating to Ophthalmic Lenses and Spectacle Frames, Part 3 (1979) : Glossary of Terms Relating to Contact Lenses.

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CHAPTER 1

THE CORRECTION OF AMETROPIA

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1.1 Introduction : Ametropia

Classically, refractive status signifies either the relation between the refracting system of the eye and its axial length, by indicating the focal length of the eye, or the position of its principal focus as compared to the position of the retina, with positive accommodation inactive (Borish 1970). Clinically, variations from perfect coincidence of the principal focus of the eye with the retina are known as refractive errors.

The theoretical focus by a perfect optical system of incident parallel rays of light from a point source would result in convergence of those rays to a single point. In an imperfect optical system, such as the human eye at its best (Borish 1970), incident parallel rays converge to form a circle which is known as the circle of least confusion. Hence, emmetropia may be defined as that refractive status wherein incident parallel rays of light converge to form the circle of least confusion upon the retina; and ametropia as that status wherein, under the same conditions, the circle of least confusion is formed:

(a) In front of the retina - myopia.

(b) Behind the retina - hyperopia.

Where a single focus for all meridians does not exist, due to differing refractive powers of the various meridians, the condition is known as

astigmatism. However, a circle of least confusion may still be determined and the astigmatism may likewise be classified according to a myopic or hyperopic division.

Traditionally, emmetropia was assumed to be the normal or desirable refractive status, and variation from emmetropia was considered to be anomalous. Generally, refractive correction procedures are designed to alter the existing refractive status towards artificial emmetropia.

A schematic illustration of the cross-section of the human eye is provided in Figure 1 (page 4). The refractive power of the eye may be considered the sum of:

(i) A series of refracting surfaces, including the corneal and lenticular surfaces.

(ii) A variety of different media indices, including the cornea, aqueous humour, lens cortex, lens nucleus, and vitreous humour.

(iii) The distance separating each surface and media change.

The refractive status is determined by the relation of the refractive power to the position of the retina : thus ametropia is often subdivided into the following categories:

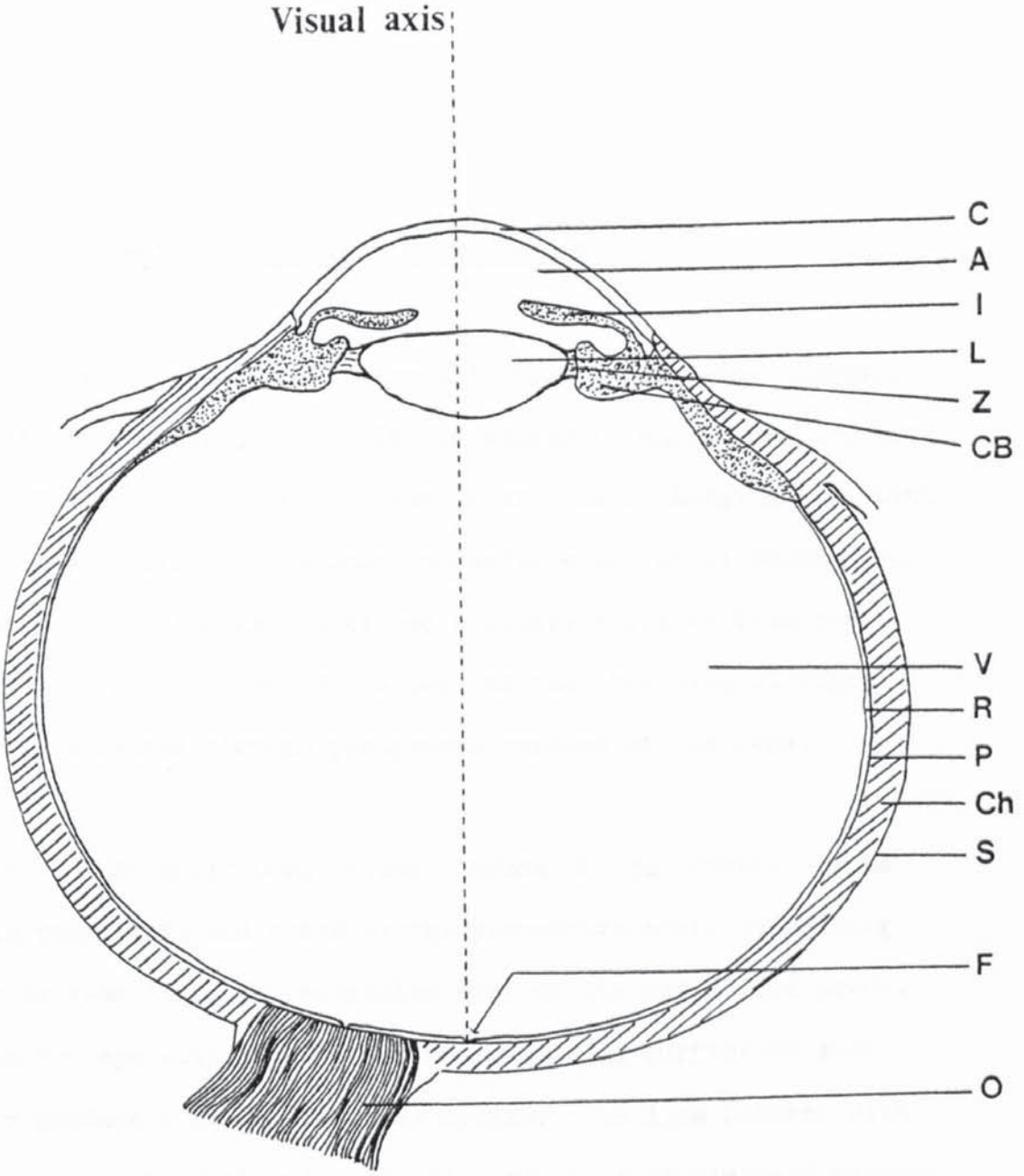
(a) Axial - in which the length of the eye is the determining factor.

Figure 1: Schematic Cross-section of the Human Eye

Key:

A	aqueous humour
C	cornea
CB	ciliary body
Ch	choroid
F	fovea centralis
I	iris, with pupil aperture
L	crystalline lens
O	optic (IInd Cranial) nerve
P	pigment epithelium
R	retina
S	sclera
V	vitreous humour
Z	zonule of Zinn (suspensory ligament)

FIG. 1



(b) Refractive - in which the refractive power of the eye is the chief factor; this is further sub-divided into:

(i) Index.

(ii) Curvature.

1.2 The Refractive Correction of Ametropia

The two principal forms of refractive aid encountered, viz, spectacle lenses and contact lenses, differ in the manner in which they correct ametropia. The spectacle lens corrects ametropia by imaging a distant object at the far point of the unaccommodated eye. It is bounded on both surfaces by air and is positioned a finite distance from the cornea. The eye rotates behind the lens so that the line of sight is frequently directed through peripheral regions of the lens.

The contact lens is positioned on the surface of the cornea. It is immersed in tear fluid and corrects the refractive state by bathing the cornea in tear fluid to neutralize most of its refractive power. It provides the eye with a new anterior refracting surface of such power as to produce a near-emmetropic system. The lens rotates with the eye so that most of the time the line of sight is directed through the central region of the lens.

1.2A Spectacle Lens Correction

The precise origin of the spectacle lens correction is obscure (Hofstetter 1948, Sasieni 1975). Certainly the introduction of the printing process in the mid-15th Century brought about an increase

in the popularity of spectacles, and a significant move was the development of a bilateral as opposed to a unilateral (monocular) correction.

Modern spectacle lenses are usually manufactured from either glass or optical plastics (Anon 1959a, 1962a, 1980). The pertinent physical characteristics of several varieties of material are summarised in Table 1 (page 7). Modern plastics spectacle lenses provide properties equal to or superior to those of glass, for all practical purposes, with the exception of abrasion resistance. Another feature of plastics lenses is that the curvature may be moulded on the lens and aspherical surfaces can thereby be provided when needed.

There are very few difficulties in specifying spectacle lens power as long as considerations are restricted to paraxial ray optics and thin leses. However, the eye moves behind the spectacle lens so that the situation is not paraxial. Spectacle lenses have finite thickness, especially in the case of convex (positive) lenses. Theoretically this would dictate the use of the principal planes in the specification of power.

Thickness can influence the refractive power of the lens. Two surfaces of constant values will produce lenses of different dioptric signs depending upon the distance between the surfaces. This effect is of primary importance in lenses of high surface curvatures such as contact lenses (vide infra : Section 1.2B pages 8 -10).

It should also be noted that the distance of the spectacle lens from the eye will alter its effective power. The effective power of a

Table 1: Physical characteristics of popular current spectacle lens materials. ‡

(After Woo 1978, Anon 1980a)

MATERIAL	TYPE	R.I.	CONSTRINGENCE VALUE	DENSITY (gcm^{-3})	REFLECTANCE (%)
GLASS:	Ophthalmic Crown	1.523	59.20	2.54	4.3
	Tital SF 64/ High-Lite	1.706	31.02	2.99	6.7
PLASTICS:	PMMA	1.491	58.00	1.19	3.9
	CR-39	1.498	57.80	1.32	4.0

‡ Optical values calculated from measurements on samples annealed at $360^{\circ}C\ hr^{-1}$

concave (negative) lens increases the nearer it approaches the eye, whereas the effective power of a convex (positive) lens increases if it is removed farther from the eye.

The correcting lens will usually produce a subjective variation in the size of perceived objects. The corrected myope will experience a decreased retinal image size, while the hyperope will experience an increase, further enhanced by his now relaxed accommodation, when wearing a correction. The astigmat may note a change in the shape of the image when he is corrected: this is due to the different magnification that accompanies the different powers of a cylindrical lens, and the patient may notice this as a form of distortion. In addition, aspects such as perspective, the fixed field of vision, and also eye movements can be altered when an ametrope is first corrected with spectacle lenses.

1.2B Contact Lens Correction

The principles of contact lens correction date back to the 16th or 17th Centuries and, in contrast to spectacle lens correction, most of the facts concerning their early development appear to be known. This historical development has been extensively catalogued elsewhere (Mann 1938, Graham 1959,1974, Jenkin 1961, Levene 1963, Bailey 1981).

The realization of the fundamental principle of contact lens correction, viz, the neutralization of the corneal power, is generally accredited to da Vinci (1508 : Ferrero 1952, Hofstetter and Graham 1953), although it was Descartes (1636 : Enoch 1956), Young (1801 :

Alpern 1948, Endore 1948) and most especially Herschel (1827, 1845 : Graham 1959) who appreciated the practical significance of the concept. Certainly by the end of the 19th Century the foundations of the use of contact lenses to correct refractive errors and neutralize corneal irregularities had been laid. However, it was in the present Century, in the period between the two World Wars, that the development of materials (notably plastics) and lens production and fitting methodologies was most marked. A significant development in more recent years has been the introduction of soft (flexible) contact lenses, in particular the commercial success of the soft hydrophilic (hydrogel) lens (Wichterle and Lim 1960, Dreifus 1978, Wichterle 1978).

The majority of contact lenses prescribed today are manufactured from plastics materials, either rigid polymethyl methacrylate (PMMA) or the flexible soft hydrophilic (hydrogel) material poly (2-hydroxyethyl methacrylate) (pHEMA). Several hybrid materials, often the result of selective co-polymerization, exist but the pHEMA variety of flexible material endures : when at equilibrium in normal saline (0.9% Sodium Chloride solution, pH7) this consists of 36.9% water (Masnick and Holden 1972).

The visual correction provided by a contact lens is a function of the optical properties of both the contact lens and the fluid medium present between the lens and the cornea. The plastics and fluid components combine to form the contact lens-fluid lens system. This system may be conveniently described as consisting of a thick contact lens and a thin fluid lens bounded by air on both surfaces. It is as if each lens were suspended in air in serial fashion before the cornea (Bennett 1963, Sarver 1963).

The thin fluid film that covers the anterior surface of the lens may be disregarded. Although it must be unbroken and of uniform thickness to provide a good optical surface, it contributes no significant power to the system.

The back vertex power of the contact lens-fluid lens system is equal to the back vertex power of the contact lens in air (F_{CL}) plus the thin lens power of the fluid lens in air (F_{FL}) (Sarver 1963):

$$F_{SYSTEM} = F_{CL} + F_{FL}.$$

So long as the fluid lens is very thin, as it is with hard corneal lenses (Sarver 1962) and minimum-clearance rigid scleral lenses (Bier 1957) this equation is clinically accurate. It should however be noted that, while a tear layer is present between a soft flexible lens and the cornea, it is minimal and afocal (Chaston and Fatt 1980).

1.3 Selected Aspects of a Comparison of the Correction Provided by Spectacle Lenses and Contact Lenses

The optical properties of spectacle lens and contact lens systems differ in many significant respects and make the visual world of the spectacle lens wearer quite different to that of the contact lens wearer (Westheimer 1962). A subject's visual response to a given lens system is strongly influenced by the visual acuity he achieves with that system, but his response cannot be evaluated solely in terms of Snellen acuity : this point will be elaborated in future Chapters. Optical properties of the lens system other than focal power will affect the total visual response, and it is the intention here briefly

to consider certain of these optical properties.

1.3A Optical Aberrations

The principal types of aberration may be listed as follows (Borish 1970):

(i) Chromatic aberration
(ii) Spherical aberration
(iii) Coma
(iv) Oblique (radial, marginal) astigmatism
(v) Curvature of field
(vi) Distortion.

As Westheimer (1961) has pointed out, aberrations of a visual aid can only be discussed in the context of the use of the device in association with the eyes. Thus, in the case of spectacle lenses, spherical aberration and coma do not play an important role because the bundle of light entering the pupil is small compared to the curvature of such lenses. On the other hand, since the eye moves with respect to the spectacle lens, distortion, oblique astigmatism and curvature of field need to be considered. Of these three aberrations, it is not usual for distortion to be specifically corrected because of the extreme curves that would be required : rather, attention is directed towards the design of (Best Form) lenses whereby the deleterious effects of oblique astigmatism and the power error resulting from curvature of field are minimized.

In contrast, contact lenses move with the eye and since, under photopic

conditions, the form vision of the peripheral retina is limited (as demonstrated by Wertheim 1894, Weymouth et al 1928, Ludvigh 1941, Mandelbaum and Sloan 1947, Anstis 1974), extra-axial imagery does not have to be of the highest quality. Consequently, so long as the lenses stay centred before the pupil, spherical aberration alone is significant : contact lenses have a relatively high curvature for their aperture. The problem of chromatic aberration does not differ in the two kinds of correction (leaving aside high refractive index glass materials) and can be ignored (Westheimer 1961).

The human eye exhibits a degree of spherical aberration although, because it is not an axially symmetric system (Bailey 1971), the amount is less than theoretical considerations would suggest (Woo and Sivak 1976). Millodot (1969,1975) investigated the variation of visual acuity with hard corneal contact lenses and with soft hydrophilic (lathe cut hydrogel) contact lenses. The results of this work indicated that the spherical front surface of the hard lens had a detrimental effect upon visual acuity, albeit only at low levels of luminance (Millodot 1969), whereas the flexible nature of the soft lens permitted the aspherical cornea to reassume its rôle of minimizing the spherical aberration of the eye (Millodot 1975).

Woo and Sivak (1976) reported no significant difference in the magnitude of monochromatic aberrations when comparisons were made between hard and soft (spun cast hydrogel) contact lenses and a situation of no contact lenses. They concluded that the effect of all contact lenses on spherical aberration (and other monochromatic aberrations) of the eye was not significant. However, this view was not entirely shared by El-Nashar (1979) following preliminary investigations of

the effects of spherical aberration upon soft hydrophilic (spun cast hydrogel) lens wear, particularly at low luminance levels.

More recently Wechsler (1978a) has investigated afresh visual acuity levels amongst groups of hard corneal and soft hydrophilic lens wearers. He concluded that the hard lenses gave better acuity, attributing the greater percentage of cases of lowered visual acuity amongst the soft lens wearers to the effects of spherical aberration (vide El-Nashar 1979) and lens surface defects.

1.3B The Accommodation - Convergence Ratio

When changing from spectacles to a contact lens ametropic correction, the myope must accommodate and converge more (and the hyperope less) when viewing a near object. This has been demonstrated with both hard lenses (Alpern 1949, Westheimer 1962, Bennett 1963, Stone 1968, Hermann 1971, Harris 1974) and also with soft lenses (Yago and Kato 1975, Carney and Woo 1977). However, no statistically significant differences have been demonstrated between the two types of contact lens correction in this respect (Carney and Woo 1977). In addition, Bennett (1963) and Stone (1967, 1968) have shown that the ratio between accommodation and convergence was almost the same with contact lenses as with spectacle lenses, under conditions where:

(i) The contact lens remained centred.

(ii) The spectacle lenses were centred accurately for distance vision.

(iii) The spectacle lens vertex distance was approximately half the distance between the spectacle lens and the eye's centre of rotation.

Harris et al (1975) could not record any statistically significant changes in binocular status when a group of asymptomatic myopes changed from spectacles to contact lenses.

1.3C Magnification

When an ametrope views a distant object through corrective lenses, the previously blurred retinal images become sharply focussed and undergo a change in size. This change in image size is termed spectacle magnification, and is defined as the ratio of the retinal image size in the corrected ametropic eye to that in the uncorrected eye, having reference to an object at infinity (Emsley 1952, Bennett 1963). It is the product of the power and shape factors of the correcting lens (Morgan and Peters 1948), although when the lens is very thin, as is frequently the case with contact lenses, the shape factor may be disregarded.

A contact lens increases the size of the retinal image for the myope and reduces it for the hyperope, relative to the size of the image formed with spectacle lenses. Hence moderately high myopes will experience a slight improvement in acuity when changing from spectacles to contact lenses as a consequence of the larger image size (Schechter 1978). In addition, a contact lens is the correction of choice for anisometropia and (monocular) aphakia.

1.3D Visual Blur with Contact Lenses

Whilst contact lenses can provide a number of visual advantages over spectacle lenses in specific instances, they may also be the cause

of certain unique visual disturbances.

1.3Di Residual refractive error

In contact lens practice, a residual spherical or, more frequently, astigmatic refractive error will obviously reduce the level of acuity. Sarver (1974) defines residual astigmatism as the astigmatic refractive error that is present when a contact lens is placed upon the cornea to correct existing ametropia. As a clinical rule of thumb, the higher the spherical refractive error, the more residual astigmatism will be accepted (Solomon 1976).

As Wechsler (1978a) has observed, there is surprisingly little discussion in the literature regarding visual acuity with hard lenses, it frequently being accepted (e.g., Sarver 1969, 1972) that acuity with such lenses does not differ significantly from the level achieved with spectacles. However, the commercial introduction of soft contact lenses in the 1960's provoked extensive discussion, this largely being centred around a comparison with aspects of existing hard contact lens wear (Ruben 1966, Wechsler 1978a). The salient point that arose from the literature was that while Snellen acuity levels with soft lenses were reasonably comparable to those obtained with other forms of correction, attention should be paid to the persistent complaints by patients of blurred or fluctuating vision outside the confines of the optometric consulting room (Larke and Sabell 1971a, 1971b, Grosvenor 1972a, 1972b, Sarver 1972).

Acknowledging that a source of this less than optimum vision could be residual astigmatism, Wechsler (1978b) has concisely reviewed the

literature regarding the reported incidence and degree of residual astigmatism in hard and soft contact lens wear. Results of a comparative study (Wechsler 1978c) indicated that, for all contact lens wearers, the elimination of residual astigmatism was no guarantee of improved acuity. Certainly in the case of soft contact lenses, the minimal tear volume under the lens (Carter 1972, Koetting 1974, Weissman and Zisman 1979a, Polse 1979) imposes restrictions upon the selection of those subjects who are suitable for lens wear : most refractive astigmatism is transferred through flexible lenses (Grosvenor 1972a, 1972b, Lee and Sarver 1972, Sarver 1972). A lathe cut soft hydrogel lens might possibly improve acuity over a similar spun cast (and therefore thinner) one (Goldberg 1973, Boyd 1974, Weissman and Levinson 1978) and, for use in certain prescribed circumstances, toric soft lens forms are available (Ruben and Guillon 1980). Even so, the general conclusion is that it is often the case that visual acuity with soft lenses is inconsistent with the amount of residual astigmatism (Grosvenor 1972a, 1972b, Sarver 1972).

1.3Dii Lens flexure effects

Over a period of time, with regular wear, it is not unusual for a thin hard corneal contact lens to become warped, distorted, or flattened with consequent alterations in vision (Morrison et al 1965). It should be noted that such alterations in lens curvature do not change the power of the contact lens in air because the front and back surface radii change to an approximately equal extent. However, the power of the contact lens-fluid lens system is changed, because front surface curvature changes are about three times as effective as back surface curvature changes in altering the power of the system (Borish 1970).

The corneal lens generally flattens aspherically, the central region of the lens becoming flatter and paracentral regions becoming steeper (Koetting 1966). The effect on vision thus depends on lens position and centration ; when a flattened lens centres before the pupil the contact lens-fluid lens system increases in minus power.

The cause and nature of lens flexure or sag in the case of soft contact lenses is rather different : a change is brought about by the flexibility and hydroplicity of the soft lens material (Baron 1978). The lenses tend to mould themselves to the curvature of the anterior corneal surface; unfortunately, there is no consensus of opinion as to the extent to which this sag of the back surface is transferred to the anterior lens surface. Several authors have advanced flexure hypotheses : these have been reviewed by Weissman and Zisman (1979b) and Chaston and Fatt (1980). Two recent papers (Chaston and Fatt 1980, Weissman and Zisman 1981) could not agree with any of these theories. Chaston and Fatt (1980) concluded that the ratio of change in front radius to change in back radius is one-half of the ratio of these radii.

1.3Diii Light transmittance and glare

For a given subject, changing from spectacle lenses to contact lenses will increase the illumination incident upon the eye for a myope and decrease it for a hyperope (although this change in illumination will have a minimal effect upon pupil size : Millodot 1970).
Unless tinted, a contact lens will typically transmit approximately 7% more light than a spectacle lens (Millodot 1967, 1970), partly because of the different absorption characteristics of the plastics

material as compared to glass, and partly due to the fact that reflection can only occur at the front surface when the contact lens is placed on the eye. This difference, resulting in an increase of 0.03 log units in retinal luminance, is reduced or reversed by the slight tint (typically ICI Tint Number 912:grey) that is often given to hard lenses for the reduction of glare and, by increasing lens visibility, for the promotion of ease of handling by the patient.

Harris and Chamberlain (1978) specifically investigated the visible light transmittance of two types of widely available hydrogel soft lenses, one spun cast and the other lathe cut. Their results for this form of correction compare well with reported transmission data for spectacle lenses and hard lenses. They found that the visible light transmittance for both types of soft lens ranged from 96% to 99% and was almost constant over the visible spectrum (range 350nm - 750nm). In addition, specific lens parameters (power, thickness, posterior apical radius) had no significant effect on the amount of light transmitted. All measurements were made on new lenses, any possible effects of lens aging not being investigated. However, Myers (1975) has reported transmittance in excess of 97% for a selection of 'used' soft lenses subsequent to removal of (primarily) proteinaceous deposits by a commercially available cleaning régime.

Glare is regarded as a sensation produced by light which enters the eye in such a fashion as to inhibit distinct vision (Wolf 1960). It is a phenomenon that has been frequently reported in connection with contact lens practice. Bergevin and Millodot (1967) confirmed that glare was more noticeable with hard (corneal) lenses than with spectacles, even after subjects had worn their lenses for periods of

several months. From the available data they considered that the reduction of acuity in their test procedure was caused by a deprivation of corneal oxygen, which thus interfered with the process of deturgescence and resulted in impairment of corneal transparency. Miller et al (1967) reached a similar conclusion following an independent study which had measured the glare sensitivity of fifty new hard (corneal) contact lens wearers.

Work by Zucker (1966) and Lançon and Miller (1973) demonstrated that a subject may manifest a visual acuity of $^{6}/_{6}$ in a clinical setting, and yet have a substantial amount of stromal oedema. The glare sensitivity was found to change significantly with relatively small amounts of stromal oedema. Thus a patient with stromal oedema may perform well visually in the consulting room, yet be significantly handicapped in instances of high levels of glare out of doors.

This point was taken up by Hess and Garner (1977). All contact lenses must produce a degree of embarrassment to normal corneal metabolism, resulting in increased hydration of the cornea : with hard lenses this is usually a localized effect, confined to the central corneal region, but with soft lenses the effect is more diffuse (Mandell 1976). Contact lens practitioners usually assess the effect of oedema on visual function by measuring Snellen acuity (Brungardt 1972), yet corneal oedema may be present with no apparent reduction in visual acuity : a more sensitive measure is therefore necessary. Hess and Garner (1977) have suggested that the contrast sensitivity function (CSF : vide Section 2.5A pages 37-43) may have potential as a general test of visual function because it measures the parameter of contrast sensitivity over a part of the visible spatial frequency range below the resolution limit itself.

1.3Div The influence of the anterior tear film and the anterior lens surface

As stated earlier (page 10), the thin film of fluid present on the anterior contact lens surface does not significantly alter the power of the contact lens-fluid lens system. It does, however, play an extremely important rôle in providing clear vision, since it imparts approximately 40 D of vergence to the incident light rays (Borish 1970).

The anterior tear film must be clear, unbroken and of uniform thickness. It must be rapidly restored to this same physical state following each blink and must remain relatively stable between blinks. If these conditions are not fulfilled, the wearer will experience a blurring of vision. This blur may be constant or intermittent, and may occur at random or at specific times in the wearing period.

The anterior lens surface must be hydrophilic to support a thin uniform tear film. Improper wetting of the lens surface is caused almost invariably by the deposition and accumulation of ocular secretions and foreign substances in and on the lens surface (Hind and Szekely 1959). This may be the result of poor personal hygiene, inadequate lens cleaning, poor hydration and wetting, excessive stimulation of the sebaceous lid glands due to poorly finished lens surface or edges, and even inadequate tear volume (Szekely and Krezanoski 1960).

Despite their hydrophilic nature, uniform surface wetting is a significant problem with soft hydrogel lenses. Deposits were observed on hydrogel lenses soon after their introduction into general commercial

use (Eriksen 1975). White films and opacities were a particular problem, necessitating many lens replacements either as a result of physical damage or simply because of subjective dissatisfaction with acuity or comfort. The identity of the deposits was not clearly established until Karageozian (1976) successfully identified the protein lysozyme. Wedler (1977) also reported the presence of proteins, along with carbohydrate and phospholipids, in an analysis of anterior surface deposits on soft lenses. Inorganic materials, notably calcium salts (Kleist 1979), have also been identified. It should be noted that mucus production is generally increased with persistent use of soft (and hard) contact lenses (Winder 1981).

Concomitant with the increasingly widespread use of soft lenses was the development of procedures to limit microbiological contamination of the hydrogel material. Favoured methods were the use of heat or of chemical preparations (Larke 1974, Phillips 1977). Nowadays it is usual to recommend that the use of either of these procedures should be supplemented by the regular (weekly) use of an enzymatic protein cleaner, e.g., papain. Recent work (Eriksen 1980) has indicated that regular use of such cleaners will decrease or remove other co-precipitated, non-proteinaceous inorganic deposits as well as eliminating the opaque protein film problem.

The use of such solutions and procedures (McClure et al 1977), along with adequate blinking (even to the extent of exercises to promote 'correct' blinking ; Stewart 1968, Korb and Korb 1970, Mackie 1970, Alexander-Katz 1971) should preserve the integrity of the anterior tear film and provide a satisfactory visual result with the majority of contact lenses.

1.3Dv The physiological effects upon the cornea of contact lens wear

A transparent cornea is a major pre-requisite for clear vision. To remain transparent the cornea must be in a state of relative dehydration (Adler 1975). When contact lenses are worn, they potentially interfere with the normal dehydrating mechanism by altering the osmolarity of the tear fluid and by reducing the supply of oxygen available for corneal tissue respiration (Langham 1952, Smelser 1952, Smelser and Chen 1955, Hill and Fatt 1964, Fatt and St.Helen 1971, Adler 1975). The resulting tissue hydration produces a turgescent cornea and visual symptoms of haze, cloudiness, or haloes which can persist for a period of time following removal of the contact lens (Kinsey 1952, Smelser and Chen 1955).

There is an important difference in the characteristics of the oedema which occurs as a result of wearing hard or soft contact lenses (Mandell 1976). The corneal oedema which results from wearing a hard lens is usually confined to a small circular or oval area in the central corneal region. The oedema which results from soft lens wear, in contrast, is spread diffusely across the entire cornea.

Spectacle blur in the hard contact lens wearer is a combination of a change in corneal curvature, the variation in curvature between the oedematous and non-oedematous area which leads to distortion, and the scattering effect of the oedema. Of these factors the curvature change is by far the most significant in producing a decrement in the visual acuity. Unless the oedema is very severe, this large corneal curvature change does not occur in the soft lens wearer : it is thus

rare to receive complaints of spectacle blur (Bruun 1977).

In conclusion, with either form of contact lens, when the aetiology of the visual blur is physiological good vision is restored by the appropriate attention to the fit and performance of the contact lens rather than to the power of the contact lens-fluid lens system.

CHAPTER 2

THE MEASUREMENT OF FORM VISION

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THE MEASUREMENT OF FORM VISION

2.1 Introduction : Form Vision

The visual perception of an object in space, while it is a complex psycho-physiological process may, for convenience, be resolved into three categories (Davson 1980):

(i) Light sense

(ii) Colour sense

(iii) Form sense.

It is the third category, the form sense, that is of relevance to the present discussion : lack of space unfortunately precludes further discussion of the first two categories. The form sense permits the discrimination of the different points of a visual image although, in the light of modern psychophysics, the use of the term 'sense' in relation to form discrimination is perhaps not strictly correct.

The structure of the visual field is determined by the power to discriminate between two or more separate stimuli with regard to their intensity and spatial size or position. The shape of an object is perceived by virtue of the integration of responses to a large number of separate stimuli of varying intensity arising from different positions on the object's surface.

2.2 The Primate Visual System

The evidence regarding human vision is largely psychophysical in origin, but a great deal of crucial information has been obtained by anatomical and electrophysiological research on the visual systems of other vertebrates, particularly cat and non-human primates (general review : Ruddock 1977).

The primate visual system, represented schematically in Figure 2 (page 27) consists of paired pathways from the two eyes, each pathway being composed essentially of three networks of nerve cells (neurones). The three networks each possess characteristic local circuitry which performs specific operations on the visual neural signals. The peripheral network, the retina, includes the photo-transducer neurones (the photoreceptors , i.e., the rods and the cones) as its first stage. Signals from the retina progress along the optic (IInd Cranial) nerve to the lateral geniculate nucleus (LGN), which then relays the nerve signals to the third neural network, the primary visual cortex. Afferent signals from the two eyes effectively remain independent of each other until they reach the visual cortex, although the two groups of signals are interwoven at the level of the LGN.

The primary visual system is characterized by a large number of laterally interacting parallel pathways, but with each pathway possessing relatively few sequential operations. This organization is in contrast to that typical of man-made machines, as observed by Von Neumann (1979).

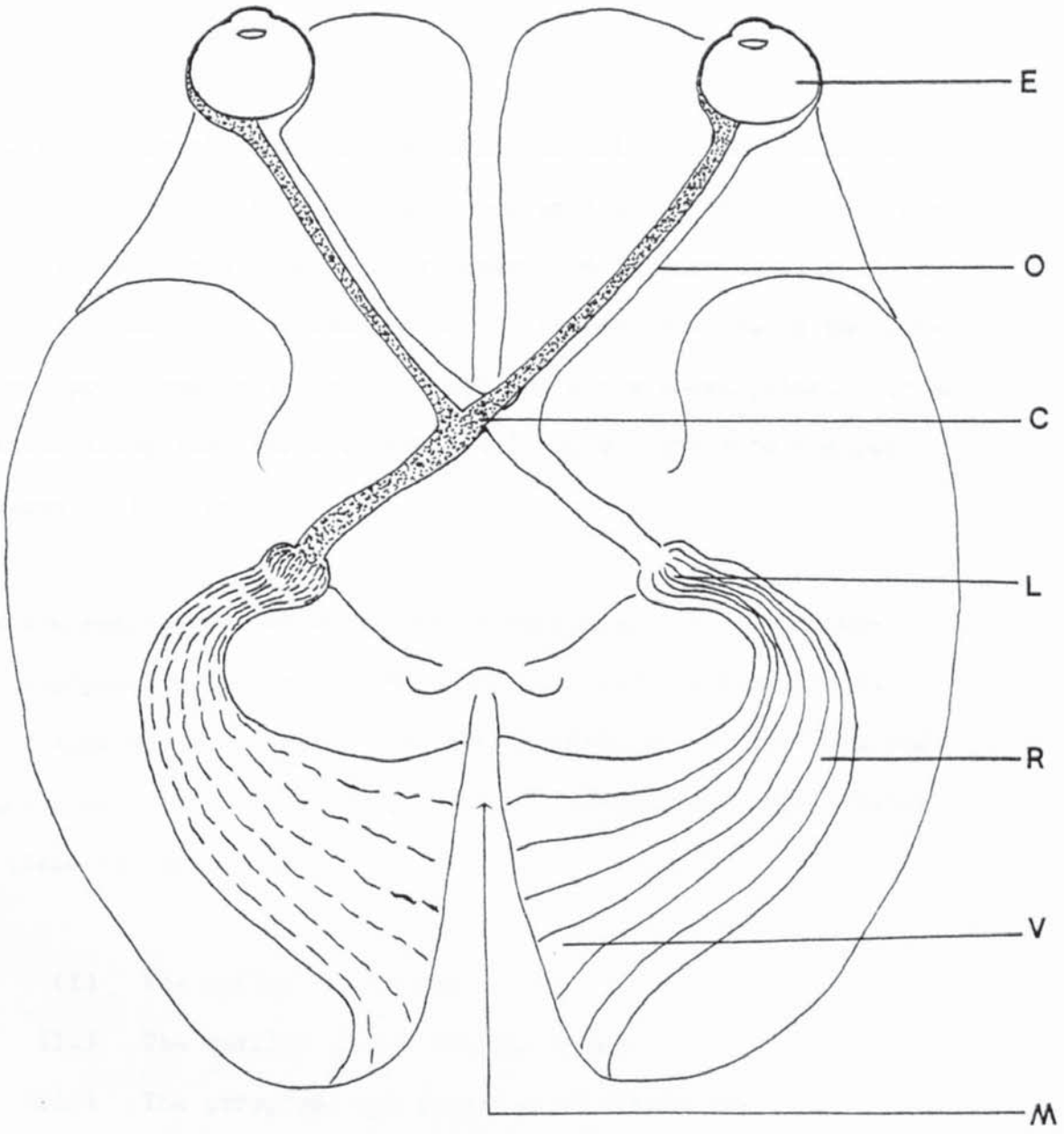
In conclusion, it should be stressed that the organization of the

FIGURE 2: Schematic view, from beneath the brain, of the primate visual system (after Ruddock 1977)

Key:

C	optic chiasma
E	eyes
L	lateral geniculate bodies
M	mid-line between the two halves of the brain
O	optic (IInd Cranial) nerve fibres
R	optic radiations (geniculo-calcarine tract)
V	visual cortex

FIG. 2



visual pathways deduced from psychophysical investigations (in practice, the determination of threshold difference values) correlates reasonably well with that found by electrophysiological methods.

2.3 Visual Acuity

Visual acuity is the spatial resolving capacity of the visual system (Westheimer 1965). It is a visual threshold where the stimulus dimension in which the threshold is determined is most usually distance. The outside world is represented on the retinal surface in two dimensions, projected as it were through the eye's nodal point. Linear distances along the retina correspond in object space to angular distances at the eye.

While the restriction of attention to thresholds, i.e., psychophysiological investigations, may be criticized (Stevens 1951), such an approach does permit a closer analysis of the physical and physiological factors underlying vision. Westheimer (1965) states that these factors comprise:

(i) The optics of the eye.
(ii) The quality of the retinal image.
(iii) The structure and function of the retina.
(iv) The capacity of the neural stages of vision for transmitting and sorting information.

2.3A The Factors Underlying Visual Acuity

If the eye possessed a perfect optical system, such that a perfect

point image were formed of a point object, the limitations to resolution would have to be sought at some other stage of elaboration of the visual impression. However, in common with all optical systems of finite aperture, the eye suffers from the effects of diffraction. This limitation, in combination with its own aberrations, depresses the eye's image-transmitting capacity. The diffraction limit depends only on the pupil diameter and the wavelength of light, if expressed in angular measure in object space of the eye[+]. Theoretically, the diffraction spread becomes less as the pupil aperture increases, but then the aberrations of the eye (primarily spherical aberration) become evident and the point image ceases to become smaller. It is not the free-field image spread itself which is of interest so much as the rate of intrareceptoral quantum absorptions; such phenomena as the Stiles-Crawford effect (Stiles and Crawford 1933) and intraretinal scatter (Vos 1963) must be remembered in this respect.

It will be mentioned here that a convenient approach to the specification of image light spread is via Fourier theory (Fourier 1822 : Westheimer 1973). Westheimer (1965, 1973) has provided brief reviews of the broad topic of Fourier theory and visual resolution. However, despite much research effort, it remains unclear as to what extent a satisfactory description of the processes underlying visual resolution may be achieved with the aid of Fourier theory, since it has been firmly established that non-linear stages are prominent in the visual system.

+ The central diffraction (Airy) disc formed by an eye with pupil diameter a mm, and for wavelength λmm, has a radius of $1.22\lambda / a$ radians.

The relationship between the light present at the retinal level and that available to the receptor pigment is complex (Enoch 1963). A brief discussion of points concerning the size and spacing of the retinal receptors is appropriate here. Several independent observations have suggested that the receptor size does not set the limit of visual resolution (Ruddock 1977). For example, acuity for grating stimuli varies with the orientation of the gratings, being greatest for vertical and horizontal gratings viewed with the head upright and reaching a minimum value for gratings orientated at 45 degrees to the horizontal (Campbell et al 1966). The receptor mosaic shows no such orientation inhomogeneity (Polyak 1941), implying that factors other than receptor size influence acuity. Of relevance to this discussion is the work of Burton (1973) : in a study employing interference fringes formed on the retina, it was established that a pair of 100% modulated sinusoidal grating stimuli, of spatial frequencies f_1 and f_2 differing slightly from each other, produced a visible pattern of 'beat' fringes of spatial frequency equal to $(f_1 - f_2)$, even when neither of the component gratings were resolved by the eye. Such a demonstration of detectable beating between two non-resolvable sinusoidal grating stimuli provides evidence that visual acuity is not determined by the finite size of visual photoreceptors (and the beating phenomenon itself provides evidence for the essential non-linearity of visual processing : vide supra, this Section page 29). In this connection also it should be noted that, in addition to Rayleigh-type resolution limits, the visual system is capable of a high degree of accuracy in alignment of straight line segments, with resolution limits for vernier acuity estimated at less than 10 s arc (e.g., 4 s arc : Hartridge 1947). It seems probable that the visual system relies on the activation of line detection mechanisms

(observed electrophysiologically) to perform tasks on a significantly finer scale than that of the receptor mosaic.

A further relevant point is that it apparently still remains to be established over what proportion of the length of its outer segment a retinal receptor can accept light (although Westheimer (1965) has stated that funnelling must occur in cones). As a consequence, a consideration of the cross-sectional arrangement of the retinal mosaic, while useful, is no complete guide, even in the (unlikely) event that it could be shown that the receptors acted as individual units. Certainly in the context of visual acuity, no such one-to-one relationship has been demonstrated. Weymouth (1958) suggested that the linkage of receptors to ganglion cells was such that receptor clusters, all acting through one ganglion cell, constituted basic physiological units accounting for visual acuity. Whilst this may well be the case, evidence is accumulating which indicates that, far from being simply summating in nature, the interaction at the retinal level is very complex, involves inhibition as well as excitation, and may vary with levels of adaptation (Barlow et al 1957). The vast possibilities for interaction have been indicated by electron-microscopic studies of retinal structure (Smelser 1961).

To summarize, the classical theory of visual resolution may be thought of as applying either to individual receptors or to groups of receptors acting as units. It requires that for resolution to occur at least one unit be stimulated differentially from the rest. So, for example, if the task is to distinguish whether an image is that of a single star or of two stars close together, it is necessary that a single receptor or unit receive less stimulation than the flanking ones; thus, a central dip in the light distribution can be

recognized, which signifies that the stimulus is that of two stars. This theory, as enunciated by Hartridge (1922), integrates the central factors underlying resolution (vide supra, Section 2.3 page 28) : optical (image light spread); anatomical (retinal mosaic); and physiological (the central dip must be at least equal to the difference limen, ΔI, at that light level).

In conclusion, it should be bourne in mind that the quantum nature of light necessarily makes the image light spread over the retinal mosaic a spatial probability distribution of quantal absorption. What is of importance is not the number of quanta falling on the retina but rather the number of quanta that are absorbed (Rose 1948). Consequently, if the quantum efficiency of absorption is low, so that only a very small proportion of the light leads to an excitatory change in the receptors, inevitable fluctuations (proportional to the square root of the number of quanta absorbed) will constitute a sizable proportion of the signal and hence will make resolution more difficult (Rose 1953). The relevant question concerning the change in quantum efficiency of the retina during adaptation has been investigated (Jones 1959, Barlow 1962), but detailed application of this thinking to the problem of resolution remains to be undertaken.

2.3B Some Parameters which Influence Visual Acuity

The acuity level depends upon a number of parameters. Verney (1958) and Westheimer (1965) have listed and reviewed the several factors which have been shown to influence visual acuity. These include (in no particular order):

(i) Intensity of illumination and contrast

(ii) Spectral nature of the light

(iii) Effect of the surrounding field

(iv) Region of the retina stimulated

(v) Lateral illumination and glare

(vi) Distance of the test object

(vii) Influence of lid pressure, tear film and blinking

(viii) Pupil size

(ix) Presence of ametropia

(x) Orientation of test object

(xi) Observation time

(xii) Binocular effects

(xiii) Age

(xiv) Stabilization of the retinal image

(xv) Eye movements and target movements

(xvi) Miscellaneous subjective factors.

2.4 Conventional Approaches to the Determination of Visual Acuity

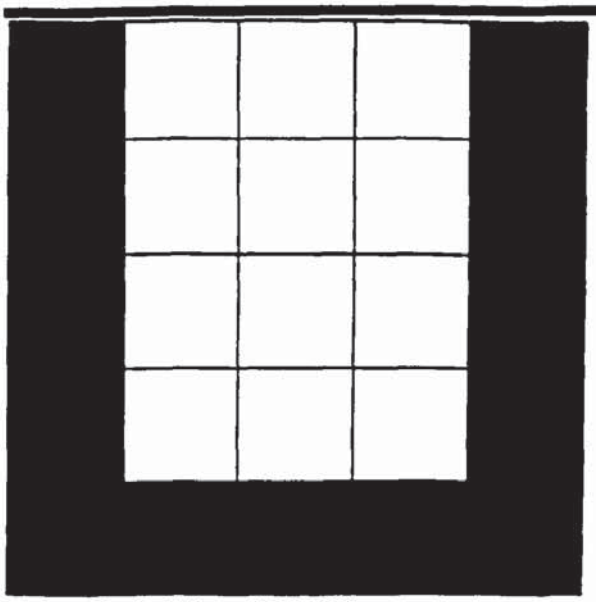
The spatial discriminating power of the eye, termed its resolving power, is the smallest angle subtended at the nodal point of the eye by two points or lines such that they are appreciated as separate (i.e., the minimum separable). Visual acuity (VA) is defined as the reciprocal of this angle when it is measured in minutes of arc (Davson 1980). Whilst the threshold of acuity will vary with the nature of the target used to determine the minimum separable, it is usual for the visual acuity of an eye to be established by determining the smallest visual angle under which the critical detail of

the particular test object can be clearly distinguished. Clinically this is conveniently achieved, at a fixed distance, by presenting objects (usually letters or symbols) of gradually decreasing size (review : Sloan 1951). Ideally, for the accurate determination of visual acuity a test is required that is "...invariable, unlearnable and repeatable" (Lebensohn 1962).

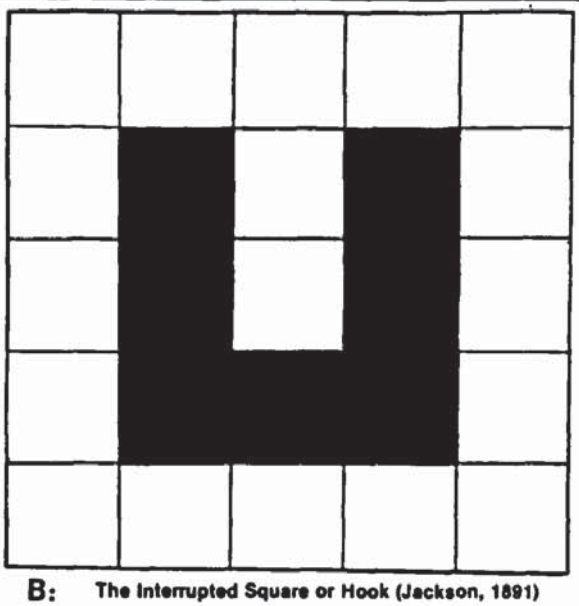
Many tests are available for the quantification of the spatial resolving power of the eye. The rationale, development and variety of the most popular test, advocated by Snellen (1862), has been reviewed by Bennett (1965). Considerable discussion has surrounded the topic of standardization of ophthalmic test types since their inception, including debates upon their style, selection, spacing and progression of sizes. In Great Britain a good measure of uniformity of testing has been achieved by the publication of British Standard B.S. 4274 : 1968 "Test Charts for Determining Distance Visual Acuity".

The broken ring is perhaps the most popular alternative test object to letters for the determination of visual acuity. Landolt's (1888) circular ring is probably the most widely used version, but other varieties exist (Figure 3 page 35). Pointer et al (1980a) have provided a review of the development of this form of test figure. Despite certain objections to its use (summarized by Pointer et al 1980a) the broken ring remains a favoured test object, although it is perhaps more frequently encountered in a research environment rather than in the optometric consulting room. There have been

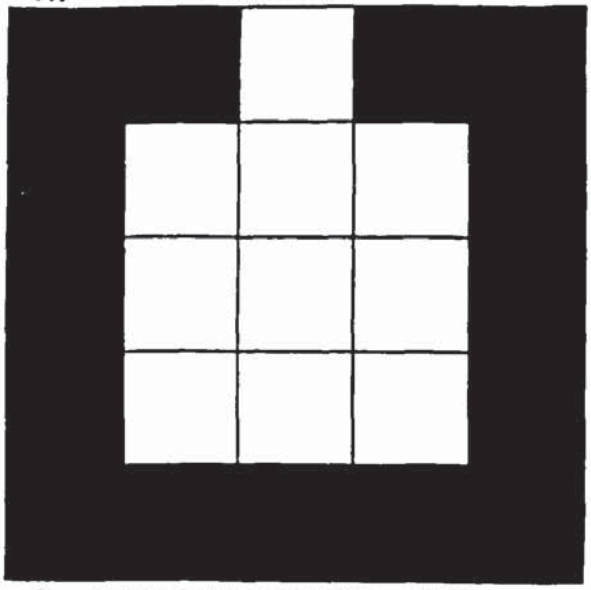
FIGURE 3: Four versions of the broken ring form of vision test object (after Pointer et al 1980a)



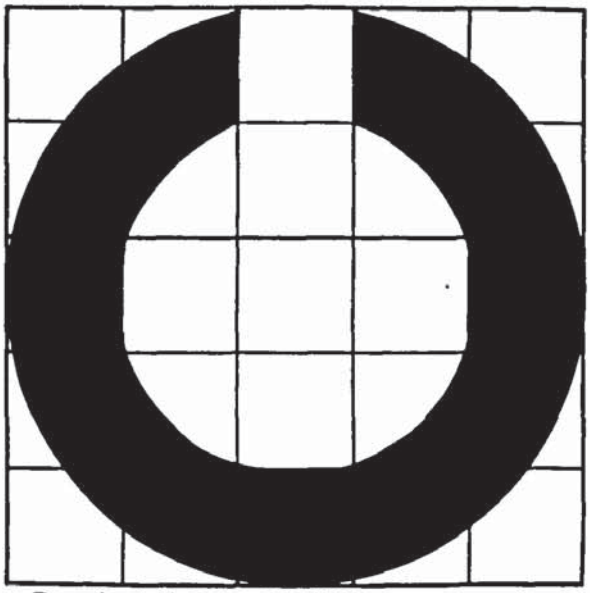
A: Snellen's Prong (1866, 1868)



B: The Interrupted Square or Hook (Jackson, 1891)



C: 'Primary Test Number 8' (Pergens, 1909)



D: Landolt's Broken Ring (1888)

several recommendations‡ regarding its establishment as a standard test object for the assessment of visual acuity. However, there seems to be general agreement with Blaskovic's (1924) contention that the break should only occur at one of the four cardinal points, viz, at the top, bottom, right or left of the figure : this is desirable when it is remembered that visual perception has been shown to be superior for stimuli aligned in horizontal or vertical orientations, as compared to oblique directions (the 'Oblique Effect', vide review : Appelle 1972).

In connection with the broken ring form of test object, the work of Flom et al (1963), Flom (1966), Tommila (1972), and Davidson and Eskridge (1977) concerned with the assessment of visual acuity level of amblyopic eyes should be mentioned. In the technique of Flom et al (1963), subjective responses to the presentation of a sequence of charts were recorded : each chart consisted of a block of eight randomly orientated broken rings of a specific angular subtense. To further raise the accuracy of testing, the plotting of a frequency of seeing curve and the determination of threshold acuity was advocated. This significantly different approach to acuity assessment,

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‡ Recommendations include:

(i) Resolutions of the International Ophthalmological Congress in 1909 (Hess), 1929 (Dufour)

(ii) Reports of the Committees of the Section on Ophthalmology of the American Medical Association in 1916, 1930 (Sloan 1951)

(iii) Indirectly, by the existence in Great Britain of Specification 9 in B.S. 4274 : 1968 "Test Charts for Determining Distance Visual Acuity"

based upon psychophysical testing methods, will be considered further in Chapter 3.

For the sake of completeness, it should be mentioned in conclusion that an alternative to the ordinary test using letters or symbols is one that uses a checkerboard (Morris et al 1955). Such tests are perhaps most frequency encountered in vision screening devices (Sulzman et al 1947). A comparative study of visual acuity measurement using selected test letters, Landolt rings and checkerboards has been reported (Sloan et al 1952).

2.5 Alternative Techniques for the Assessment of Vision

2.5A Modulated Grating Patterns and the Contrast Sensitivity Function (CSF)

The ability to perceive sharp outlines of relatively small objects is of enormous practical importance. However, the ability to perceive slight changes in luminance between regions which are not separated by definite borders is of equal importance (Arden 1978). In clinical practice it is only the first ability which is tested, by means of the high contrast ophthalmic test types. However, patients who complain of visual disturbance, including those whose visual problems are related to the wearing of contact lenses, may have acuities of $^{6}/_{6}$ or better, and it is often the case that such patients cannot describe precisely what the change in vision is like.

To summarize, since much visual information is presented in terms of the tint, tone and texture of surfaces which have no definite boundary,

the assessment of an individual's sensitivity to contrast increments within his visual field is clearly of practical and clinical significance.

Campbell and Green (1965a) first measured the sensitivity of the human eye to contrast using sinusoidal grating patterns. The use of such targets represented an important advance, since it provided a simple means of investigating and specifying visual resolution over the working range of spatial frequency and contrasts.

Two basic parameters of a grating pattern can be varied : the spatial frequency and the modulation or contrast (Figure 4 page 39).

A particular advantage of a sinusoidal grating is that, although its image is degraded by aberrations and diffraction, the distribution of light in the image will still be in the form of a sinewave, although of lower amplitude (Abadi 1974). Thus the perception of low spatial frequencies is not limited by the refractive properties of the eye, a useful clinical point. Further, the sinusoidal pattern is also particularly simple, in that it contains only one spatial frequency presented in one meridian and is readily applicable to Fourier transform and linear systems analysis (Westheimer 1973, Abadi 1974).

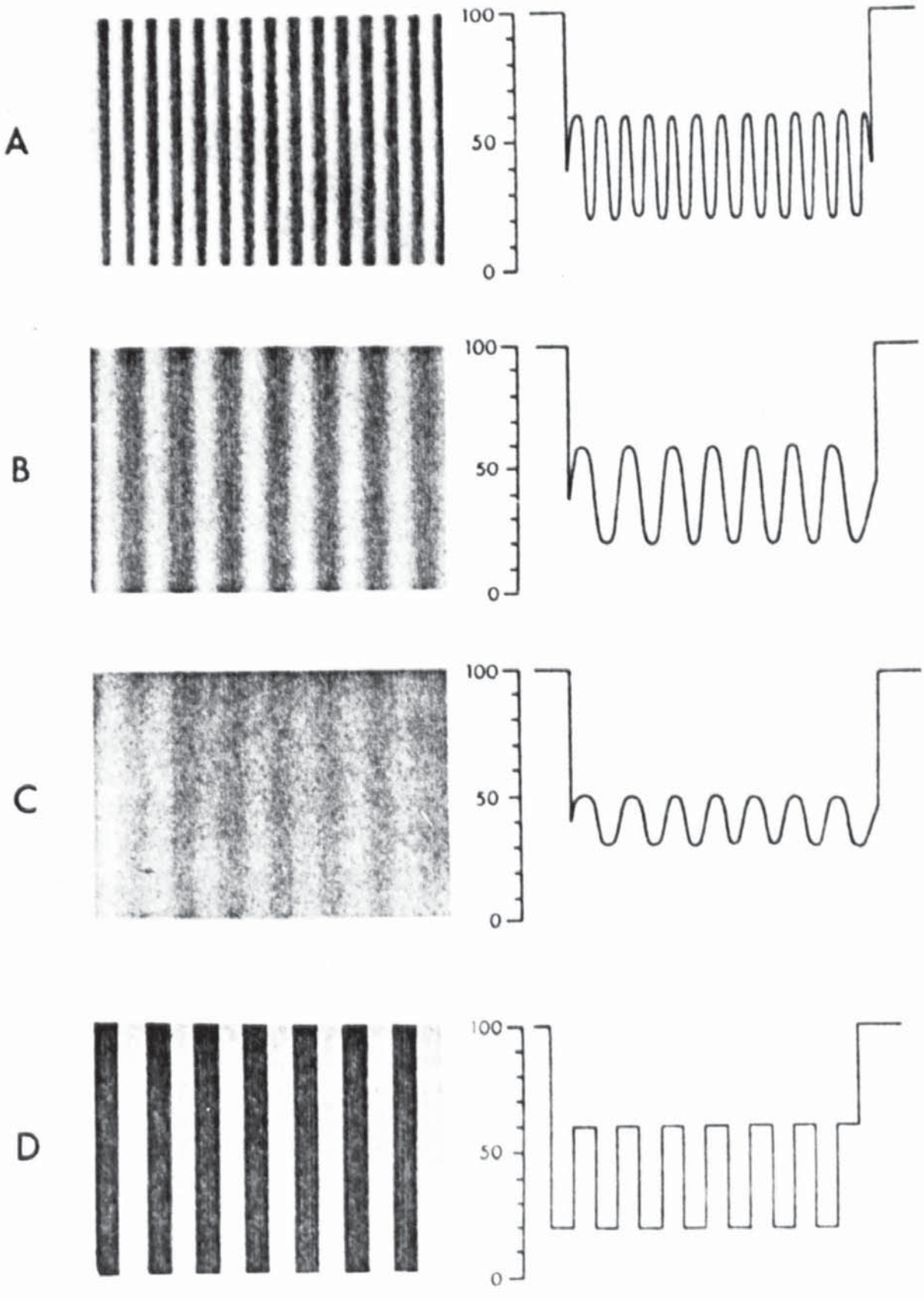
Although the basic neurophysiological mechanisms underlying spatial contrast sensitivity are still not entirely understood, the use of sinusoidal gratings has shed considerable light on the problem. Early work by Enroth-Cugell and Robson (1966) used micro-electrodes to obtain responses of cat retinal ganglion cells to such stimuli. Arden (1978) presents a very brief summary of progress over the last

FIGURE 4: Examples of modulated grating patterns

(after Arden 1978)

Key: A,B and C are sinusoidal gratings, D is a square wave pattern. A and B differ in spatial frequency, B and C in contrast.

Contrast is defined as:
$(L_{MAX} - L_{MIN})/(L_{MAX} + L_{MIN})$,
where L is the luminance recorded by a microdensitometer scanning across the gratings. This is diagrammed to the right of the Figure.


A
100
50
0
B
100
50
0
C
100
50
0
D
100
50
0

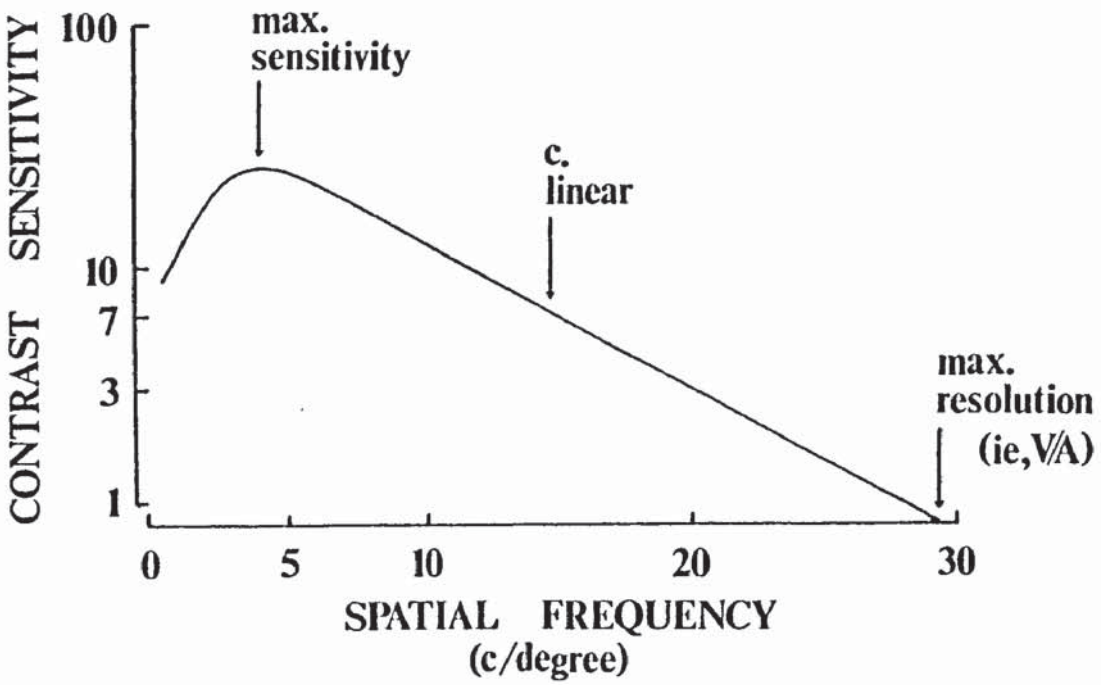
decade and a half, observing that although sinusoidal gratings do not occur naturally they do seem to depend on a basic visual function in that there are probably several visual channels handling separate spatial frequencies.

The techniques for the production of modulated gratings are now well established, largely as a consequence of the published work of Schade (1956) and Campbell and Green (1965a). Refinements to equipment and presentation are still being made (e.g. Faulkner 1978). However, the major clinical disadvantage with all these methods centres upon the prolix manner of testing. Sekuler and Tynan (1977) indicate that they have developed a speedier procedure, still using standard instrumentation. Meanwhile Arden (1978) has described a rapid screening procedure (the Arden Grating Test, AGT) which utilizes printed test plates of selected sinusoidal gratings : clinical trials have produced promising results (Arden 1978, 1979, Feeley 1980, Skalka 1980a). In all these tests, however, the basic approach is very similar : a test area containing a sub-threshold sinusoidal grating is presented to the subject and the contrast is then increased until the modulations become detectable. This procedure is repeated several times, to obtain contrast or modulation thresholds for grating targets of different spatial frequencies. The reciprocal of the threshold value, i.e., contrast sensitivity, is then plotted as the logarithmic ordinate against spatial frequency (number of cycles per degree of visual angle) as the abscissa to obtain the typical bell-shaped curve of the spatial frequency contrast sensitivity function (CSF : Figure 5, page 41).

The function typically has a maximum sensitivity around three cycles

FIGURE 5: The typical form of the contrast sensitivity function curve (after Abadi 1974)

FIG. 5


CONTRAST SENSITIVITY
100
10
7
3
1
max.
sensitivity
c.
linear
max.
resolution
(ie,V/A)
0
5
10
20
30
SPATIAL FREQUENCY
(c/degree)

per degree. Past this peak a marked increase in contrast is required to detect grating patterns. The decrease in sensitivity with finer gratings (the high frequency 'fall-off') is very steep. Thus small changes in grating size are accompanied by large changes in contrast sensitivity. The 'cut-off' point or the finest detectable grating (corresponding to the visual acuity value) can be easily extrapolated from the contrast sensitivity curve, which follows an exponential function common to all normal observers (Campbell and Green 1965a).

However, this accuracy is not the only or even the major reason why gratings are useful in acuity assessment. The greater portion of the high frequency leg of the contrast sensitivity curve covers the region of the Snellen chart between $^{6}/_{6}$ and $^{6}/_{12}$ vision. It may be considered that the measurement of grating contrast sensitivity expands this region of the scale (Bodis-Wollner 1975). The establishment of grating contrast sensitivity is thus of special interest when vision is considered 'borderline' or not of an entirely satisfactory level.

It has been demonstrated that the contrast sensitivity function may be modified in several different ways. It is as much the overall shape of the curve as the point where it intersects the abscissa which is of importance in any attempt at elucidating the often very subtle visual changes reported by subjects. Thus, in summary, the grating method yields not only a more precise measurement of visual acuity but also information unobtainable by more conventional methods (Westheimer 1973, Bodis-Wollner 1975), since the latter determine only one point of the contrast sensitivity function, the intersection with the abscissa. It should also be stressed that, unlike the Snellen-

type assessment, the end point of the test is the recognition of either uniformity or non-uniformity of a field, not the detection of the presence of a pattern with distinctive spatial frequency (Westheimer 1973).

The use of the CSF technique in several areas of contact lens practice has been reported. These include, for example, its use in contact lens design (Townsley 1971); in the detection of the presence of (sub-clinical) corneal oedema (Hess and Garner 1977); to assess residual refractive errors (Applegate and Massof 1975); to investigate aspects of soft contact lens wear (Applegate and Massof 1975, Rosenblum and Leach 1975, Larke and Pearson 1977, Woo and Hess 1979).

2.5B Visually Evoked Response (VER) Acuity

The classical use of the Snellen chart to determine acuity on a subjective basis has endured principally because it is a test which is relatively easy to standardize and requires a minimum amount of instrumentation (Skalka 1980b). However, as Section 2.5A (pages 37 and 42) has discussed, functional loss of acuity may not be accurately reflected by tests of high contrast resolution such as the Snellen letters. The visually evoked response (VER) provides an approach, albeit essentially in a research environment, to the accurate evaluation of vision.

Regan (1980) has observed that the aim of the majority of workers who have used evoked potentials to assess vision has been to obtain an objective measure of visual acuity that agrees with behavioural

estimates. The establishment of a new scale of measurement ('evoked potential acuity') has not been seriously attempted.

Recently Skalka (1980b) has compared Snellen and VER acuities in conjunction with the scores obtained with Arden's (1978) Grating Test (AGT), in a sample group of patients exhibiting a variety of macular and optic nerve diseases (specifically excluding any person with significant media opacities). He concluded:

(i) Snellen acuity proved most resistant to degradation by less severe macular and optic nerve disease states, i.e., is a poor screening test.

(ii) The VER approach and the AGT were equally sensitive means of assessing vision in diseases of the optic nerve.

(iii) The AGT proved, on the whole, to be the most discriminating of the three testing procedures in detecting abnormalities, and was easily superior to VER acuity as an early indicator of macular dysfunction.

A serious disadvantage associated with VER recording, even with modern electronic apparatus, is that it is costly, elaborate, and relatively time consuming, and is difficult to standardize between laboratories. Skalka (1980b) has concluded that VER testing is simply too demanding of time, resources and interpretation to be practical in the evaluation

of the acuity of large numbers of subjects, despite being sensitive to optic nerve (transmission) anomalies. In addition, by varying stimulus size and contrast the AGT has incorporated two of the major parameters which the researcher would be interested in evaluating with sophisticated VER stimulators.

2.5C The Border Enhancement Phenomenon

When two areas of unequal but uniform luminances adjoin abruptly, the contrast at the border thus formed is enhanced by the visual process. Thus, the darker area appears to have a band of deeper darkness along the border, whereas the brighter area exhibits immediately next to the border of band of greater brightness. This is the phenomenon of border contrast enhancement (Figure 6, page 46).

The phenomenon undoubtedly has much in common with Mach band formation. However, the stimulus and response are of a smaller order than in classical studies on Mach bands, for the slope of the luminous gradient approaches infinity. Remole (1977a) remarks that, although many parallels can be drawn between the two phenomena, they must not be equated uncritically. Since there is much disagreement as to what happens to Mach bands at an abrupt border (Mathews 1966, Shipley and Wier 1972), it is not clear to what extent border enhancement should be considered a special case of Mach effects.

The methods employed to measure Mach effects can also be applied to border enhancement. Wildman (1974) applied the concept of gauging the peaks and troughs of the subjective brightness across the enhanced region. Remole (1976 et seq.) preferred to measure the width rather

FIGURE 6: The phenomenon of border contrast enhancement

(after Remole 1976 et seq)

Key:

Schema of stimulus response:

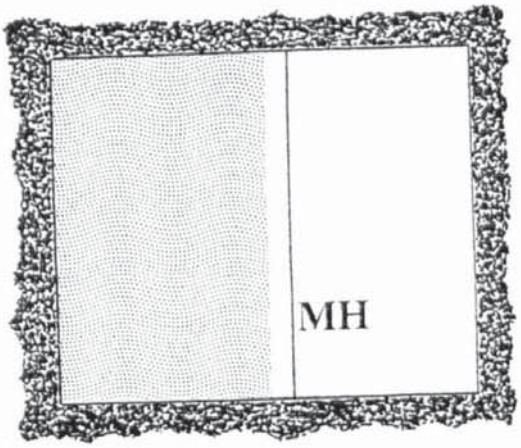
A — Bipartite field with measuring hairline indicator (MH)

B — Luminance distribution of the two fields

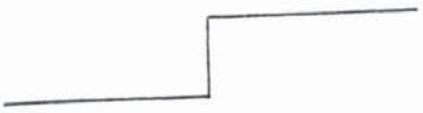
C — Corresponding subjective brightness distribution near the border : S_1 and S_2 spread of brightness and darkness enhancement from border

FIG. 6

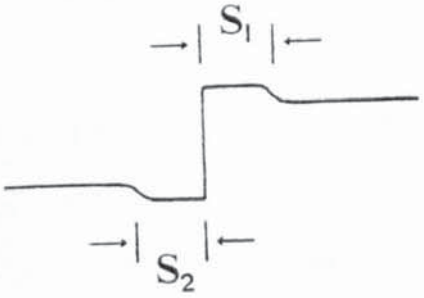
A.



B.



C.



than the brightness of the bands, using a faintly illuminated hairline indicator (Figure 6 page 46). Remole (1974) has demonstrated that the spread of the enhanced region follows the size of the fundamental blur circle in the retinal image even when no blur is subjectively perceived.

Remole (1977a, 1977b) has indicated that a potential application of the border enhancement phenomenon lies in the examination of the vision produced by a contact lens correction for ametropia. As an investigative technique it has shown itself to be sensitive to the effects of (narrow angle) scattered light (Remole 1977a) and also retinal defocus (Remole 1979). In both these respects it was certainly more sensitive than conventional Snellen acuity (Remole 1977a, 1977b, Hess and Garner 1977), and even more sensitive that the measurement of contrast thresholds (Remole 1979, 1980). The degrees of corneal oedema produced by hard and soft contact lenses of various specifications and fittings could be assessed by reference to the degree of light scattering produced (Remole and Callender 1978). In addition, the subtle change in retinal image quality attributable to the difference in thickness of standard and ultra-thin soft contact lenses could be established (Remole and Callender 1979).

However, in conclusion, one drawback should be noted. Remole (1977b) makes the point that, while with appropriate instrumentation the test is not difficult to perform, if the technique is to be applied in a clinical environment it would have to be simplified. In its present form, it is more suited to the research laboratory where it can be used, for example, to compare the ocular response to various contact lens designs or to monitor the presence of small amounts of corneal oedema.

2.5D Miscellaneous Objective Tests for the Determination of Visual Acuity

In conclusion, a note may be made of the several objective procedures available for determining the level of acuity. The value of such techniques lies in the examination of the vision of the very young or the elderly, the mentally handicapped, malingerers, and also in rapid screening procedures.

Voipio (1961) has divided the existing methods into four groups, the procedures being based upon either evoking or, alternatively, arresting an optokinetic nystagmus (the most commonly employed techniques, according to Millodot et al 1973), on evoking a pendular (oscillatory) eye movement, or on the use of galvanic skin responses. Testing is usually undertaken under conditions of monocular viewing, the particular test object being viewed by the subject's eye that is under examination. Pearson (1966) has provided a comprehensive review of studies in this field.

Most recently, a clinical version of a proven research technique for accurately assessing acuity has been introduced. It was Le Grand (1935) who first outlined a method, based on the production of interference fringes upon the retina, for the measurement of retinal function independently of the refracting media of the eye. Lotmar (1972, 1980) has described a simpler method for the assessment of retinal visual acuity using Moiré fringes. Lotmar (1980) states that results with his instrument compare favourably with visual acuity assessment by other techniques.

CHAPTER 3

VISUAL PERFORMANCE

CHAPTER 3

VISUAL PERFORMANCE

3.1 Introduction : The Concept of Visual Performance

'Visual performance' is a frequently encountered but rarely defined term. Its use in the literature has generally been associated with the delineation of a visual parameter somehow more expansive than the rather specific indication of the acuteness of vision as determined by the conventional Snellen letters.

It is the field of illuminating engineering which provides the most numerous references to visual performance, albeit often within the wider context of human performance or efficiency (McNelis 1973, Overington 1976). Human performance may be resolved into a three-stage activity : vision-cognition-action. As McNelis (1973) recognized, the visual aspect is of fundamental importance : poor or inadequate visual input will limit the certainty of the perceptual process, and during the final stage poor visual activity will result in an inaccurate response.

These same considerations are valid if attention is restricted to visual performance : the statement of visual acuity level is relevant, but only insofar as it is reflected in the precision of the perceptual and response aspects. As Applegate and Massof (1975) have observed, in the specific context of soft contact lens wear, the recording of visual acuity is only a limited measure of visual performance. Qualitative in addition to quantitative information is required in the assessment of visual performance : there is a need for the provision

of a measure which takes into account the four fundamental variables associated with an object of visual regard. These variables, as defined by Cobb and Moss (1928a, 1928b), comprise:

(i) The size of the object's critical detail.

(ii) The contrast between object and its background (Colour is logically a sub-variable here).

(iii) The brightness level to which the object and its background is illuminated.

(iv) The presentation time.

These variables are not listed in any order of importance; in any particular visual task any one of them may be critical, but its limiting value will depend entirely upon the values of the other three. Fry and Enoch (1959) and Weston (1961) have independently demonstrated this point; further, Weston (1962) has shown that an increase of size has a greater effect on improvement of visibility for objects of low contrast than for those of high contrast. However, Hopkinson and Collins (1970) stress that no simple relation between size and contrast can be expected.

Of Man's five senses vision is claimed to provide some 75% of the total input to the brain about his environment (Overington 1976). As previously discussed (vide supra this Section page 50), the eye as the organ of sight and the brain (primary visual cortex) as the organ of interpretation operate together in determining a subject's visual performance. Consequently, any assessment of visual performance requires that consideration be made both of the processes of vision and of the geometrical and photometric characteristics of the visual field.

As Hopkinson and Collins (1970) observe, it is probably true to say that more is known of the characteristics of the eye as an optical instrument than of the characteristics of the brain as an interpretative mechanism. Thus it is often the case that work associated with the determination of visual performance is concerned with the optics of the situation rather than with its interpretation at higher levels.

3.2 Some Major Studies of Visual Performance

A brief review of several approaches to the investigation and assessment of visual performance as found in the literature will now be made, in an attempt to further elucidate the concept. Hopkinson and Collins (1970) have summarized the major methods of study of visual performance under two broad headings. These comprise the observation of the effect of size, contrast and speed of perception upon:

(a) The actual performance of a simplified representative task - the direct method:
Weston (1945, after Beuttell 1934), Bodmann (1962)

(b) The threshold of perception - the indirect method : Blackwell (1959)

In addition, the important studies of Fry and Enoch (1959) and Vasa (1960) will also receive attention, these being of particular relevance to the procedure outlined in Section 3.3Bii (pages 71 to 73) and described more fully in Section 4.3 (page 79 et seq.).

3.2A The Performance of Simplified Representative Tasks

Following the proposal of Beuttell (1934), Weston (1935, 1945) created an artificial visual task which was well suited for the direct study of visual performance. He devised a test card upon which was printed a display of two hundred and fifty-six Landolt broken rings, arranged in sixteen blocks of four rings wide by four rings deep (i.e., a total of sixteen rings per block). The broken rings were all of the same size and contrast for a given card, but the breaks in the different rings were randomly orientated in different directions. The same pattern of rings could be used over and over again, because the card could be orientated in four different directions and there were eight different positions of the break which could be used in the test. A number of different test cards were provided, with the size of the rings and their contrast varying from card to card; the latter parameter was altered by the simple expedient of varying the reflectance of the paper upon which the rings were printed. The luminance level could also be controlled by varying the illumination that was falling on the card.

The test procedure for the administration of this visual inspection task was intentionally straight-forward. Under constant conditions of luminance, a first test card was placed on the table at a distance of anything up to 0.5m in front of the subject who was instructed to cancel, with a pencil, the rings which had their breaks orientated in a specific direction. The method of search was left up to the subject to determine, although most apparently tended to work along each line of rings, in an orderly and systematic manner, from left to right. The subject was timed whilst he undertook this task. On

completion a second card was presented to him; this had the rings which were orientated in the given direction blocked in with red ink for easier identification, and again he was timed whilst he worked through the display merely cancelling these rings. Weston (1945) assumed that the time required to cancel a single red-marked ring on the second card was equivalent to the time required to cancel a ring in a regular run using the first card after it had been located and identified as having a gap orientated in a given direction. The subject's performance of the task was then scored as outlined in Table 2 (page 55). Performance as determined by this approach can be seen to depend upon both accuracy and speed, exactly as is required by the majority of industrial and office tasks (Hopkinson and Collins 1970). Recent confirmation of the durability of the Weston-type task has been provided by the use of a similar test (Weisz 1979) in connection with the evaluation of performance in a clinical therapy (accommodative training) programme.

Bodmann (1962, 1967) devised a test method which was a direct development in principle of that of Weston, but which involved the measurement of speed of performance for 100% accuracy. The test also combined objective measurements of performance (speed) with subjective assessments of satisfaction with the illumination level provided. The experimental procedure was not unlike a game of bingo, the visual search times for each number called being recorded. The size of the type face used for the numbers and the contrast of the type with the background were both varied, as in Weston's approach.

TABLE 2: Weston's (1945) direct method for the assessment of visual performance using a simplified representative task : the stages in the calculation of a subject's index of performance.

1.	ACCURACY FACTOR, A	=	Total no. of rings correctly cancelled / Total no. of rings which might have been correctly cancelled
2.	TIME FACTOR, T_1	=	Time required to complete the task (Card 1) / Total no. of rings correctly cancelled
3.	TIME FACTOR, T_2	=	Time required to complete the task (Card 2) / Total no. of rings correctly cancelled

NET TIME required to find and identify a specified ring,

$$I = T_1 - T_2$$

SPEED OF IDENTIFICATION $= 1/I$

$$\text{WESTON'S INDEX OF PERFORMANCE} = A \times {}^{1}/_{I}$$

3.2B Performance and the Threshold of Perception

Crouch (1958) has reported that in the United States of America Blackwell had been studying basic parameters of visibility for military use since early in the Second World War. Blackwell's indirect approach was based upon fundamental determinations of the influence of various factors upon visual performance : the threshold information thus produced then had to be translated into conditions corresponding to practical situations by means of some empirical field factor.

In the extensive studies on threshold contrasts by Blackwell (1959), the threshold of detection was determined by presenting a luminance difference at the centre of a field of uniform luminance; this field extended over at least 30 degrees in all directions from the central fixation point. The size, contrast and duration of presentation of the luminance increment which comprised the stimulus was varied as the brightness of the test room was raised. Thus, as Fry (1962) has stated, the several studies of Blackwell have yielded data which have proved very useful for evaluating the effect of size, contrast, luminance and duration upon frequency of seeing.

Blackwell's work will not be elaborated further as it is aimed at aiding the illuminating engineer in specifying illumination requirements for certain locations and for tasks of various levels of difficulty, and as such is not strictly relevant to the present discussion.

3.2C Automated Approaches to the Assessment of Visual Performance

Fry and Enoch (1959) and Vasa (1960) have both used a different kind of task to study visual performance as compared to those described in Sections 3.2A and 3.2B previously. They observed that the temporal aspects of a visual task involve rate as well as duration of presentation. Consequently, in the similar tasks devised by these investigators, the rate and duration of stimulus presentation or exposure was controlled by an automatic timing device. Randomly orientated Landolt broken rings were presented intermittently and the subject was required to indicate in which of the four cardinal directions he believed the single break to be orientated. The subject had no control over the speed of presentation, and variations in his performance could be detected only by changes in accuracy. In a given series of presentations (which constituted a run) the luminance of the background and size and contrast of the broken ring was kept constant, as was the rate and duration of the exposure ; the orientation of the gap alone was varied. In the Fry and Enoch (1959) experiment the subject indicated his response by moving a joystick in one of four directions; in Vasa's (1960) work the subject pressed one of four buttons. The luminance of the surround field was kept equal to that of the immediate background of the stimulus, but there was a slight colour difference which made it possible to differentiate the immediate background from the surround. This chromatic contrast border was used to control the direction of the fixation during the interval prior to presentation of the stimulus. Both experimental investigations took place in a dark room, and at a viewing distance of 5m.

The use of intermittent exposure made it possible to analyze the performance in terms of frequency of seeing. The subject was instructed to guess if he was not convinced that he was actually seeing the orientation of the gap (the method of forced choice). Thus, at the end of a given series of presentations, information had been accumulated as to the total number of exposures and the number of exposures called correctly. An allowance or correction was made for guessing and the frequency of seeing was determined. For a given size of ring, duration and rate of presentation, and brightness of background, Fry and Enoch (1959) and Vasa (1960) were able to determine frequency of seeing values for various levels of contrast. These values could then be plotted as a function of log contrast, and the data fitted with a curve which was the integral of the probability curve. Fifty per cent frequency of seeing was usually defined as the threshold level.

Important differences between the similar studies of Fry and Enoch (1959) and Vasa (1960), and the work of Weston (1945) must be recognized. In the former experiments, the subject was always looking in the direction of the centre of the ring, so that the image of the ring fell at the fovea; in Weston's work the image of the ring to be cancelled need not have been falling at the fovea when it was first found and identified. Furthermore, in Weston's study the subject only had to indicate when he had found the ring with the gap orientated in a given direction; he did not have to react to each ring as he reacted in the other experiments. Thirdly, in the Fry and Enoch/Vasa experiments the subject had to respond to each presentation before the onset of the second presentation in order to get credit for his response. This had a tendency to encourage the subject to

drop all phases of the operation connected with one stimulus as soon as the second appeared, so that with each new stimulus he started afresh. In contrast, in Weston's study the subject may have been inspecting one ring while still reaching some decision about the ring he last fixated and which he still saw indirectly, or while he was indirectly inspecting other rings which he expected to fixate later. Even while he was marking a defective ring, he could be inspecting other rings directly or indirectly.

From the Fry and Enoch/Vasa experiments, the time that a subject allowed himself for processing the information from one exposure could be determined. These workers found that a large percentage of the time required for perception of the orientation of a gap was related to processes at the cortical level involved in deciding where the gap was located. By increasing the rate of presentation the reaction time could be decreased, but this penalized the accuracy. They found that, on the whole, the subjects expressed a preference for a rate of about one presentation per 3s, although a rate of one every 2s could be tolerated without a serious loss in quality of performance. At this rate the subjects reported that they did not feel rushed but rather that they had all the time that they desired and, of equal importance, did not feel that they were wasting time undertaking a boring task.

The Fry and Enoch/Vasa studies also revealed an interesting relationship between reaction time and difficulty of seeing of the stimulus. If the interval between successive stimuli was long, and the subject knew that he had all the time he could possibly use, there was a gradual increase in the reaction time as the contrast or size or

luminance was reduced to make the visual task more difficult. Ultimately there came a point at which the subject realized that he was merely guessing, gave up trying to see and made a guess. Even before the stimulus was presented he could determine what his next guess would be. Consequently, at the more difficult levels of seeing, where it became a matter of guessing, the reaction time might be very short. When the interval between stimuli was short and the subject realized that he must react as quickly as possible in order to get credit for his response, he used more time for high levels of seeing than for (more difficult) intermediate levels of seeing. One interpretation of this result (Fry 1962) was that a subject must compromise between responding before it is too late and delaying to be a little more certain. The easier the task the greater was the temptation to delay.

Fry and Enoch (1959) performed a subsidiary experiment in which they let the subject pace himself. The results emphasized the importance of allowing a subject to prepare for the second stimulus. In this particular instance no eye movements were required, it merely being a matter of concentrating attention on the anticipated stimulus. This point has an important bearing on a future discussion (Sections 3.3Bii pages 71-73 , and 4.3Avi, pages 104-106). As Fry (1962) has observed, this finding may represent a way in which automatic presentation may be preferable, because it can introduce an interval between the response to one stimulus and the onset of the next. This is not possible in a Weston-type study because, as Fry's (1962) investigation of the pattern of eye movements has shown (vide page 62), there is no appreciable interval between fixational pauses. The length of the fixational pause represents the reaction time to the stimulus to

which the eyes are exposed; the eye movement at the end of the pause represents the response, and there is no possibility of introducing an interval between the response and the next stimulus.

3.3 The Assessment of Visual Performance

The objective of the research effort reported herein was to devise and evaluate a procedure to facilitate visual performance investigations upon subjects wearing refractive aids, more particularly upon those subjects wearing soft contact lenses. In establishing such a measure attention was to be paid to certain key test parameters, viz, the size of stimulus detail, the contrast and illumination level of stimulus and background, and the stimulus presentation time (Cobb and Moss 1928a, 1928b). In addition, Fry and Enoch (1959) and Vasa (1960) have stressed the importance of attending to the rate as well as the duration of stimulus presentation : this is a view shared by Sarver (1972) in connection with the monitoring of soft contact lens vision.

A sequel to the advocation of an approach incorporating temporal appraisal is the possibility that psychophysical test procedures and threshold measures may be used to quantify the visual result. This is an approach frequently commended in the literature for its accuracy and flexibility, not only in the general investigation of the effects of certain variables upon levels of vision (Lythgoe 1932, Blackwell 1948, 1952, 1953, Graham 1965), but also in specific instances, for example, the precise investigation of vision in amblyopic eyes (Flom 1966, Davidson and Eskridge 1977). However, it should be borne in mind that the potential gain in accuracy brought about by using threshold measurements may be at the expense of applicability.

A further aspect which should receive attention, especially in the context of the quality and stability of soft contact lens vision, is that of eye movements, including blinking. Fry (1962), as part of a careful evaluation of the work of Weston (1945), developed the original Weston-type task in order to incorporate a study of the effects of stimulus contrast and size, and the overall level of luminance, upon the subject's pattern of eye movements, paying particular attention to the fixation pauses. In a pilot study of human performance, McNelis (1973) remarked that the recording of eye movement patterns provided useful information relating fixation time and duration to the difficulty of the seeing task. However, the use of blink frequency as, variously, an index of performance, task difficulty, or effort in visual work, has long been the subject of controversy amongst psychological investigators. As York et al (1971) have observed, a review of the literature does little to resolve the problem. Possibly the most honest conclusion is that drawn by Wood and Bitterman (1950), who stated: "...rate of blinking is not... a very sensitive or reliable index of performance".

The devising of instrumentation to assess visual performance falls into two stages : firstly, the choice of the physical form or configuration of the test stimulus; and secondly, the most suitable means of presentation of the chosen stimulus.

3.3A The Form of the Test Stimulus

A decision was made to use a test stimulus of similar design to Landolt's broken ring. This form of test stimulus has the advantage of being well documented from the time of its introduction by Landolt

(1888). The original objective of such a test symbol was to provide, as an alternative to test letters, a stimulus of uniform legibility for the determination of visual acuity : its merits and demerits in this context have been reviewed by Pointer et al (1980a: et vide Section 2.4 page 34). In addition, it is a test pattern which may be easily and accurately constructed (i.e., printed, drawn, photographed). Its regular form also lends itself to automated presentation and investigation procedures.

However, as has already been described (vide Section 3.2A, pages 53 -55 , and Section 3.2C, pages 57-61), its utility as a test stimulus has been both consolidated and extended by its incorporation in visual performance and illumination studies. These studies include:

(i) The use by Lythgoe (1932) of the detection - type visual task posed by the broken ring to investigate the effect of the luminance of the surround to a visual task on the minimum size of detail in the task which can be resolved. This work has been extended by Foxell and Stevens (1955) who, still using the broken ring, studied the effect of different sizes of surround field at various luminance levels.

(ii) The study of visual performance by the observation of the effect of size, contrast and speed of perception upon the actual performance of a simplified representative task (Weston 1945, after Beuttell 1934).

(iii) The similar studies of Fry and Enoch (1959) and Vasa (1960), which investigated the effect of such variables as size, contrast, luminance of background, rate and duration of presentation upon the speed and accuracy of detecting the orientation of the break in a Landolt ring, in an analysis of the rôle of vision in the performance of a task. Fry and Enoch (1959) cited the use of such a test stimulus by, notably, Weston (1945) as a major reason for its selection for use in their study of visual performance. In addition, they cited the work of Perrin and Altman (1953) which had indicated that the Landolt ring gave a measure of visual acuity which fell near the median of the measurements yielded by a group of commonly used resolution targets.

Attention should be paid also to the following reported work:

(iv) Prince and Fry (1956, 1958) used experimental apparatus similar to that subsequently described by Fry and Enoch (1959) in an investigation of the effect of uncorrected spherical and astigmatic errors of refraction upon levels of acuity.

(v) As Section 2.4 (pages 34-36) has described, the broken ring has found wide-spread acceptance as

a standard test object. It is frequently encountered in vision studies; for example, in the assessment of acuity levels in amblyopic eyes (Flom et al 1963, Flom 1966). There is also a report of its use in the subjective determination of acuity levels in non-human primates (rhesus monkeys : Farrer and Graham 1967).

Several alternative means of vision assessment have been described in Chapter 2. Of these techniques, the VER acuity and the border contrast enhancement index were, for reasons already discussed (Sections 2.5B page 44 , and 2.5C page 47 respectively), not seriously considered as being feasible approaches to the investigation of vision in the project to be reported herein. The complex or unorthodox nature of both the techniques could be seen to pose potential problems in the anticipated clinical environment of the work, not least of these problems being in conjunction with the possible size of the subject groups and the number and frequency of experimental data collection visits over the duration of the project.

A rather more serious contender was the use of the contrast sensitivity threshold measure. This is becoming a widely used and accepted technique in research studies and as discussed (Section 2.5A page 42) permits the assessment of the quality of vision for object sizes within the resolution limit rather than merely defining the limit itself (i.e., visual acuity). However, there exists a certain amount of reticence with regard to the use of this technique in a clinical environment. This largely centres around the means

of generation and appearance of the test stimulus. Sinusoidal gratings can be produced by interference techniques (Campbell and Green 1965a, Green 1970), but more usually they are generated electronically on the viewing screen of an oscilloscope. Such displays are generally restricted in field size, spectral composition and range of illumination levels. More recently televised displays have become available, their advantages being (Arden 1978) that the image is much larger and brighter, and the equipment is much less expensive. High-quality studio monitors are required to display small contrast differences, but they are not too expensive, and have a much greater long-term stability than conventional oscilloscopes. The disadvantages are that there is often a small residual flicker apparent on the screen, and it is difficult to produce certain forms of display (for example, oblique or drifting gratings) which might be required in experimental but not necessarily in clinical work. Subjectively, television displays are very well tolerated. Faulkner (1978) has provided a description of suitable television equipment. Such an approach makes testing simpler and the determination of the contrast threshold more rapid.

The logical progression from this technique, albeit with a slight reduction in experimental precision, is embodied by the Arden Grating Test (Arden 1978). This test, designed for use at near, could conceivably be modified for presentation at greater distances. The contrast thresholds so obtained would not, of course, be the same as those found with the standard psychophysical (forced choice) techniques but could be calibrated against them.

However, from a consideration of the range of variables which visual

performance has been taken to encompass (vide supra, Section 3.3, page 61) and the clinical bias of the work, it was decided that the contrast sensitivity approach would not be pursued. In the visual environment of the soft contact lens wearer especially, where poor quality and instability of vision is a consequence of lens movement and flexure on the eye, it is conceivable that modulated gratings would, in practice, be of limited application in resolving what is essentially an optical rather than a neural problem. Further, Woo and Hess (1979), having determined the CSF of several subjects wearing soft contact lenses noted, where a subject reported intolerance to the lenses, that there was a reduction in contrast thresholds, most especially in the high frequency range. While not being certain of the exact nature of the reduction, Woo and Hess (1979) felt that this finding was suggestive of an aberration effect not amenable to refractive correction.

Thus, in conclusion, the decision to use the well established broken ring test object seems reasonably well founded for the nature of the experimental investigation envisaged.

3.3B The Means of Presentation of the Test Stimulus

3.3Bi A discussion of the possible options

The precise manner in which the test stimulus is presented to the subject is the key to its successful use in the proposed investigation of visual performance. Having decided upon the broken ring as the chosen form of test stimulus, perhaps the obvious starting point is to consider the extrapolation of a Weston-type task (i.e., displays of

Landolt broken rings) to 6m. Larke and Pearson (1977) broadly adopted such an approach, producing a small selection of charts on white translucent plastic panels which could be conveniently slotted into the main panel aperture of conventional internally illuminated test cabinets. On each chart a selection of Landolt rings were presented, being of uniform contrast and with their breaks randomly occurring in one of eight possible positions. The distribution of ring sizes down each chart was also entirely random, unlike conventional Landolt test panels, but there were always five rings on each line. When directed to a particular ring, usually starting in one corner of the chart, the subject was required to verbally indicate in which of the eight possible positions he felt the break to be located.

Photo-reproduction methods were utilized to obtain several charts with rings of various intensities, whereby the effects of contrast differences could be investigated. (It should be mentioned that Spicer and Ensell (1973) have reported similar work using Snellen letters, at various contrast and luminance levels, in conjunction with a threshold determination approach.)

Whilst Larke and Pearson (1977) reported that the results of this simple test procedure indicated the feasibility of the approach (in very general terms), the technique was felt to be unsatisfactory on two main counts.

(i) Technical shortcomings:

(a) There were several manufacturing and technical difficulties encountered, notably

regarding the production of rings of consistently reduced contrast; for every good photograph produced there were several unsatisfactory ones, obviously costly in terms of the time and expense involved.

(b) It proved very difficult to maintain a constant mean level of luminance from the chart when altering the contrast between figure and ground, despite neutral density filter overlays.

(c) Comparison of results was not always possible, due to uncertainties as regards external and chart illumination.

(ii) Subjective problems:

(a) The main difficulty from the operational point of view centred around the manner of presentation. There was insufficient control over the time allowed for decision making with individual targets; as one would anticipate, the larger rings promoted relatively quicker responses than the smaller ones, and thus presentation and decision times tended to be decidedly inconsistent.

(b) With this type of testing one was clearly too dependent upon the general disposition and degree of co-operation of the subject.

These points have since been corroborated by the present author, after a few short trials with a group of experimentally naïve subjects using some of the original charts.+ Indeed, two points of experimental procedure readily became apparent: firstly, single target presentation was to be preferred; secondly, as advocated by Blackwell (1952), the psychophysical method of constant stimuli with forced choice responses should be used, in preference to a self-pacing approach, to determine the visual threshold.

In an attempt to satisfy these criteria, the use of a series of individual presentations on transparent slides or on a continuous roll of film was considered. However, both procedures were found to have a number of drawbacks, in addition to the persistent problems of the accuracy of photo-reproduction already encountered. With transparent slides the immediate problem centred around the sheer number of slides required for successful operation. The multiplication of the four experimental features, viz, the number of different stimulus sizes, the number of possible stimulus orientations (e.g., four or eight), the number of different levels of contrast, and the duplication necessary to prevent memorization by the subject, would quite easily produce several hundred slides in a battery, a decidedly unwieldy means of experimentation.

The use of a continuous roll of film would provide a smooth and easy change from one stimulus to the next, but would be a rather inaccessible and inflexible means of presentation. Also, one would

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+ Charts kindly loaned by Mr A S Pearson

be restricted to the sequence on the roll, which would necessarily have to be lengthy in order to again avoid the subject remembering the sequence. Finally, with both these methods one would encounter problems regarding the uncertainty of inter-stimulus adaptation.

The possible automation of the presentation procedure by the use of cine or video film would also introduce unwanted variables, notably flicker effects. There would also be a degree of uncertainty over the exact area of retina which was being stimulated.

It is worthy of note here that wide-screen projection systems have been suggested for human performance studies (Vunderink and Sanders 1975). These have utilized both flat screens (for example, of dimensions 9m wide and 2m high) and also cylindrical screens (for example, covering areas of angular subtense up to 120 - 180 degrees). Whilst such arrangements could be considered to be ideal for the presentation of complex stimuli, and could possibly provide a more flexible experimental approach than television displays (which are the next logical option in the presentation discussion), they are hardly a practical proposition in a clinical environment. Their use in the literature does seem to have been directed towards the wider field of human rather than, specifically, visual performance investigations. A recent example is their use in connection with studies involving the simulation of the steering and manoeuvrability of supertankers at sea (Wagenaar 1975).

3.3Bii The method adopted : a television system

It was eventually decided (Larke and Pearson 1977) that the presentation

of individual electronically-generated broken rings on a monochrome television screen could offer the best solution to the problem. This approach, in addition to providing a high degree of control over the presentation of stimuli, also had several unique advantages:

(i) Screen luminance levels could be controlled with a good degree of certainty, provided that there was no significant variation in, for example, the voltage of the mains alternating current electrical supply.

(ii) In addition, a virtually constant mean screen luminance level could be maintained, independent of changes in relative contrast between stimulus and background. This is a unique feature of television tube imagery.

(iii) There was a built-in uniform adapting field between each stimulus presentation, thereby eliminating possible effects arising from transient adaptational phenomena.

(iv) At the design stage, stimulus presentation was arranged to be as flexible as possible within the constraints of finance, time and availability of expert technical assistance imposed upon the project.

The resulting automated test equipment will be described more fully in Section 4.3 (page 79 et seq.). It was in many ways similar to

the earlier mechanical test apparatus described by Prince and Fry (1956); single broken rings were presented with accurate and reliable control over their size, position, orientation, level and type or direction of contrast. It was also possible to vary the duration of exposure and the time interval between each stimulus presentation. The subject registered his response to each stimulus on a push-button panel, and a built-in electronic counter monitored and recorded the total numbers of correct subjective responses.

CHAPTER 4

A DEVICE TO ASSESS THE VISUAL PERFORMANCE OF THE HUMAN EYE

CHAPTER 4

A DEVICE TO ASSESS THE VISUAL PERFORMANCE OF THE HUMAN EYE

4.1 Introduction : Television (TV) Displays

The last two decades have seen the extensive commercial exploitation of the rapid developments within the often complimentary fields of micro-electronics and computer science. This has resulted in their diversification into areas previously not associated with such advanced technology. So, for example, the utilization of the television screen to display information (the visual display unit : VDU) is now no longer the sole preserve of, notably, the air traffic controller; the advent of personal computers and television games has considerably widened the applications of this device.

The use of television (TV) in a clinical environment has been reported: Weaver and Oliver (1973) successfully used a portable transistorized monochrome TV set in the optometric consulting room as a rather elegant distance fixation target. It was felt to offer a more flexible approach with regard to the choice and range of parameters of the presented stimuli than, for example, a transparent slide or ciné film projector system. Equipment breakdown was also considered to be less of a potential problem. Being transistorized, the 'warm up' time was considerably shorter than with the older tube (valve) - type models, a significant feature in connection with clinical schedules. Modern electronics facilitated remote control. It should be noted that only the video portion of the televised signal was utilized : the audio

portion had no place in an optometric environment, in this particular instance.

Closed circuit television (CCTV) has been extensively developed for use as a visual aid in cases of subnormal visual acuity (Potts et al 1959, Genensky 1969, review : Silver and Fass 1977).

TV displays are reported subjectively to be very well tolerated (Arden 1978). This is no doubt a reflection of the most recent (1979) figures published by the United Kingdom Government Statistical Service (Anon 1980b), which revealed that 95.8% of British households have the use of a TV receiver.

Also of interest in connection with the utilization of advanced technology in a clinical environment is the work of Crossman et al (1970), who have described a computer-based automatic method for clinical visual acuity determinations. It should be stressed that they envisaged the coupling of such a specific automated assessment to other similarly computer-assisted procedures in the routine optometric examination (e.g., refraction : Marg et al 1969). Their ultimate aim was to produce a package system which would generate data for subsequent interpretation by a clinician. Thus, although the test procedure as described involved the use of single four-position Landolt broken rings as the stimuli and a joystick control for subjective indication of response (c.f., the methods of Prince and Fry 1956, and Fry and Enoch 1959), in conjunction with a psychophysical test procedure with forced choice responses (the randomized double staircase method : Cornsweet 1962), the intention was merely to present a fast and efficient method for the determination of visual acuity. Stimulus

presentation was by random-access (carousel) slide projection, although it was acknowledged that a TV display would probably be a feasible alternative.

4.2 The Production of Pictures on a TV Screen

Fink (1963) has provided a review of the history and development of TV systems, including a discussion of the fundamentals of picture transmission and reception. The conceptual base of the modern electronic TV system was laid down by Campbell-Swinton (Great Britain) and Rosing (Russia) in 1907 (Fink 1963) : these workers independently suggested the use of cathode rays (electron beams) for the reconstitution of the transmitted image at the television receiver. The cathode-ray tube (CRT) had been developed by Braun (1897 : Fink 1963) to trace curves on a phosphor surface. A schematic cross-sectional diagram of a TV picture tube is provided in Figure 7 (page 78).

A prime requirement for the production of a TV picture of acceptable quality is that it does not flicker, since flicker induces severe visual fatigue. Flicker becomes more evident as the brightness of the picture increases. A stable view is obtained by projecting each image twice, i.e., each TV image is analyzed and synthesized in two sets of spaced lines, one of which fits successively within the spaces of the other. Thus, the picture area is illuminated twice during each complete picture transmission although each line in the image is present only once during that time. This technique is feasible because the eye is comparatively insensitive to flicker when the variation of light is confined to a small part of the field

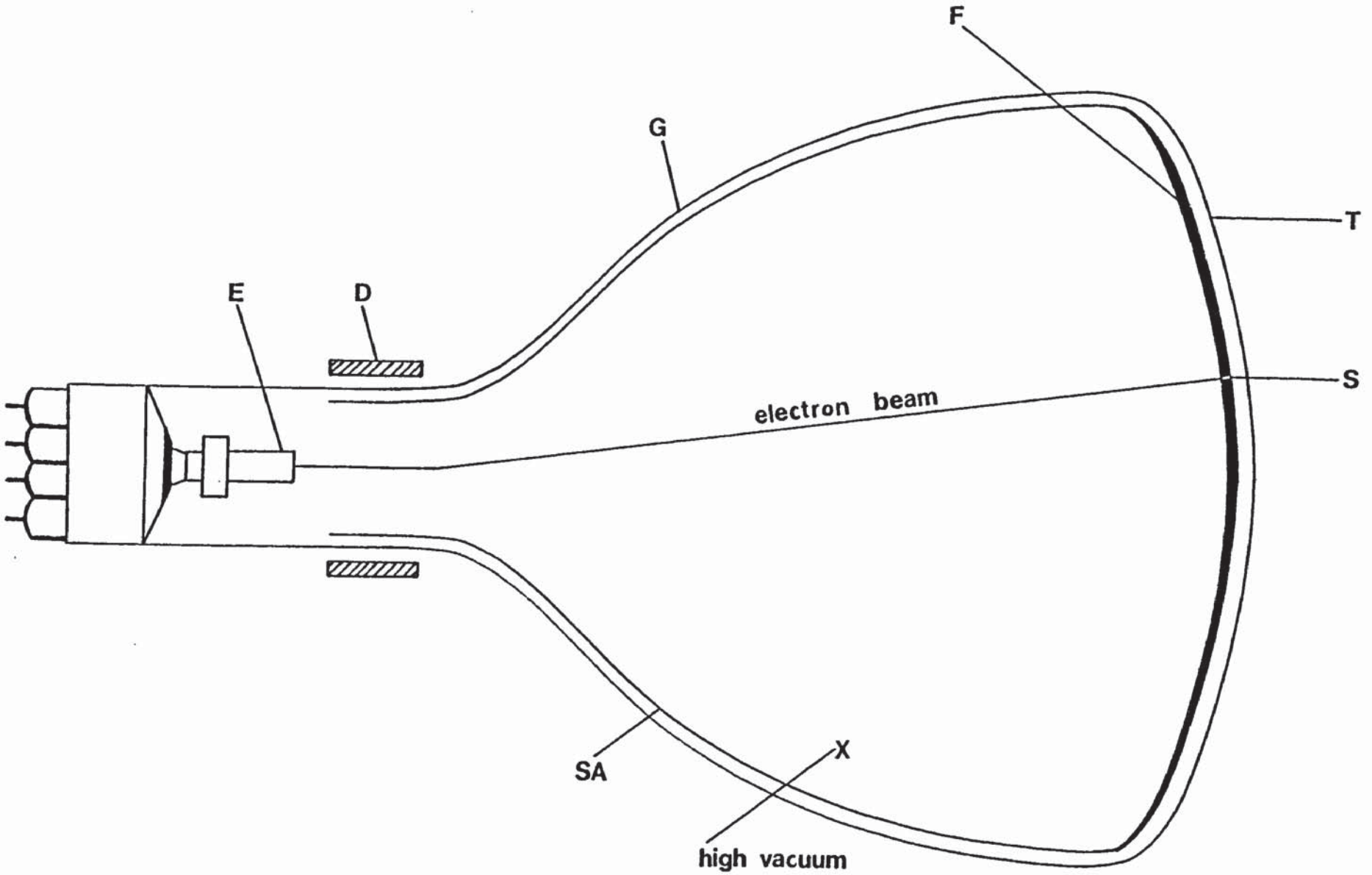
FIGURE 7 : Schematic cross-sectional diagram of a cathode-ray tube

(after Fink 1963)

Key:

D	deflection yoke (horizontal and vertical coils)
E	electron gun (cathode, control electrode, cylindrical sleeve of first anode)
F	fluorescent viewing screen (phosphor layer with aluminium back-coating)
G	glass envelope
S	scanning spot
SA	second anode (graphite coating)
T	tube face (curved glass)

FIG. 7



of view. Hence flicker of the individual lines is not evident. In Great Britain, where the mains electricity supply is rated at 50Hz, the TV picture rate is twenty-five per second (fifty screen illuminations per second). Needless to say, interference effects or 'noise' arising from, for example, the electronic circuitry, must be minimized or eliminated to further promote optimum TV picture quality (Baldwin 1954).

The shape of the TV picture has been standardized universally as a rectangle whose width is one-third longer than its height, the four by three (4 x 3) aspect ratio. (The width of the screen rectangle is greater than its height, as in the proscenium of a theatre, to accommodate the horizontal motion which predominates in virtually all televised events.)

The path over which the TV picture structure is explored on the viewing screen is a series of parallel straight lines, each progressing from left to right, the lines following in sequence from top to bottom of the picture frame. The exploration of the image structure proceeds at a constant speed along each line. This is the scanning process, the agent being the scanning spot, and the path it follows being known as the scanning pattern or raster.

4.3 A TV System to Assess Visual Performance

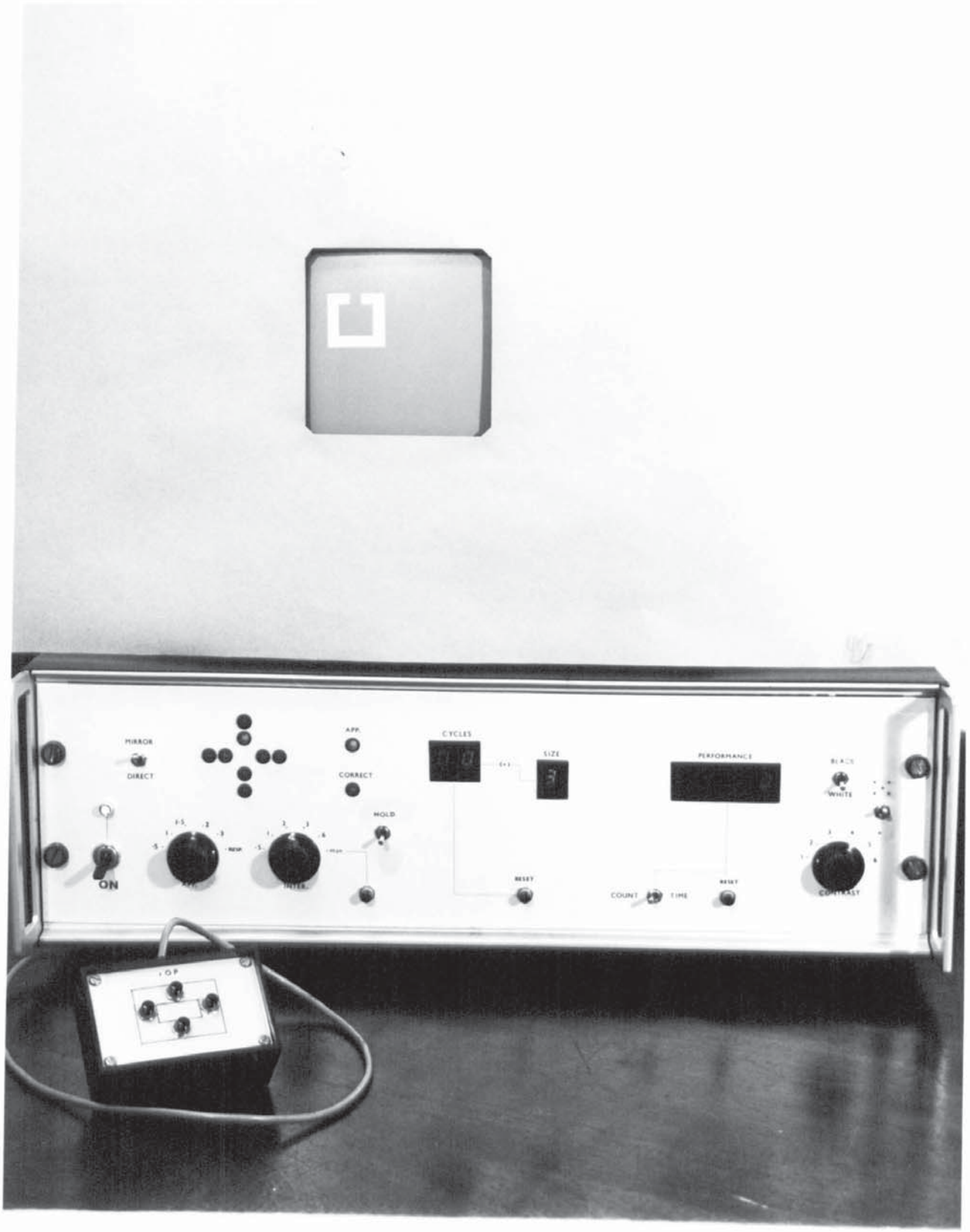
A description will now be made of the instrumentation devised and constructed to assess the visual performance of the human eye which is wearing a refractive aid, i.e., a spectacle lens or a contact lens (Pointer et al 1980b, 1981). With this system it was possible to

FIGURE 8 : Photograph of the TV system

The TV set (hidden behind the uniform neutral grey cardboard viewing mask) is mounted on top of the instrument cabinet containing the electronic control circuitry. In the foreground can be seen the subject's hand control box with the four push-button indicators.

The system's controls are set such that the broken ring stimulus is being presented at positive contrast and at a contrast-per cent level of c.55% (control setting 1).

N.B. The dark reflex present around the periphery of the exposed area of TV screen at the aperture in the viewing mask is an artefact produced by the high level of illumination in the photographic studio : it was not present during normal operation of the TV system under the usual conditions of ambient illumination in the test room. (This point should also be remembered when viewing Figures 11-13, pages 101-103).


MIRROR
DIRECT
APP.
CORRECT
CYCLES
SIZE
PERFORMANCE
HOLD
ON
RESET
COUNT
TIME
RESET
WHITE
CONTRAST

generate electronically an angular version of Landolt's (1888) broken ring test figure, and display the same on the viewing screen of a portable transistorized monochrome TV receiver (Figure 8, page 80).

It should be noted that the system when first constructed differed slightly in certain respects from the system to be described here. As was anticipated at the time of construction, informal trials with the basic design indicated certain weak areas including, for example, the unsuitability of the range or scale provided for particular parameters. Consequently, alterations were made and whilst reference will be made to them, the following description of the equipment and test situation refers to the experimental set-up as used in all the work for this project.

4.3A The TV System Variables

4.3Ai Physical details of the TV set and the viewing screen

The TV set used in this work was a modified Philips^{R} portable transistorized monochrome domestic receiver, running on the standard Great Britain 240 volt ac, 50Hz mains electricity supply.

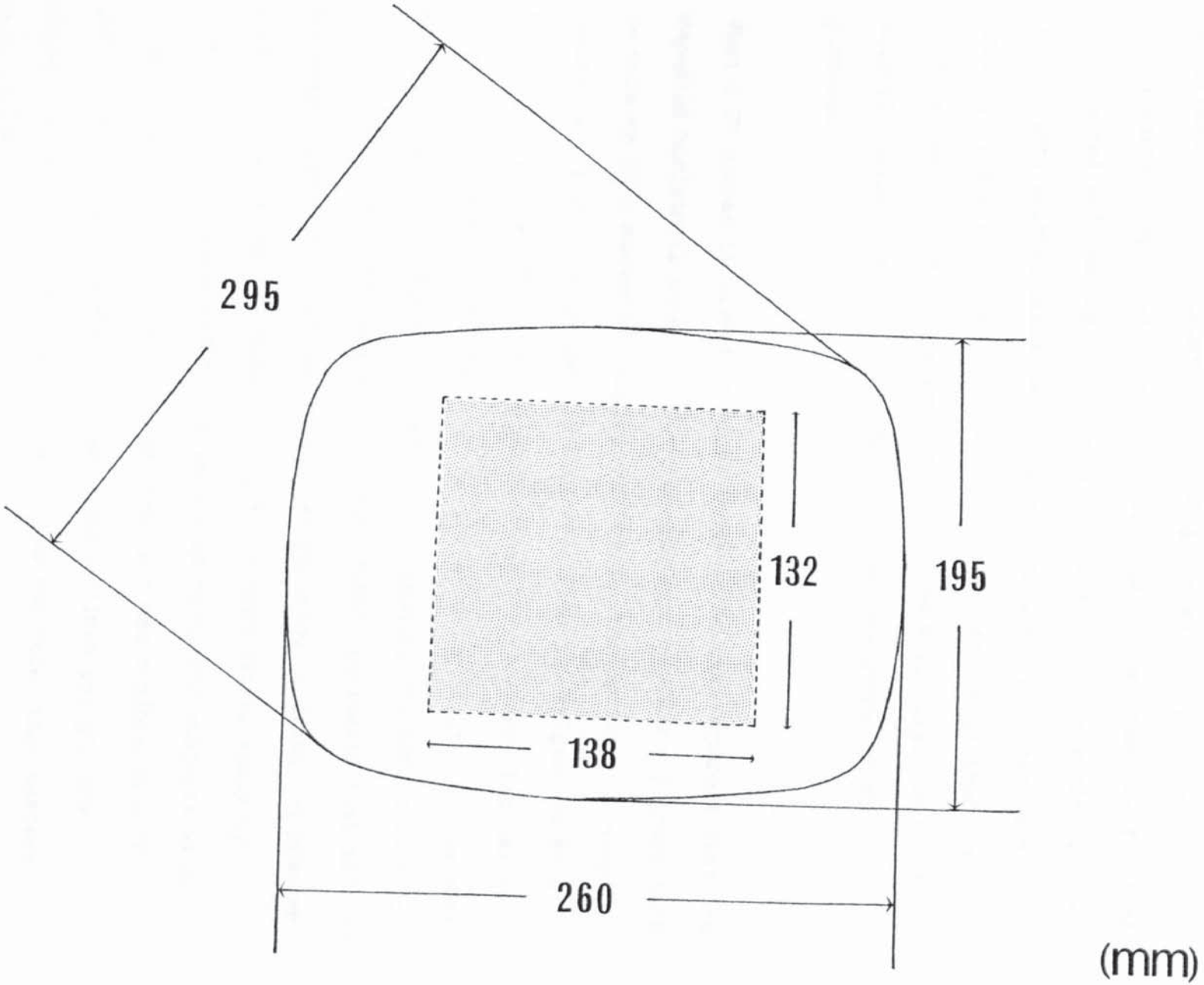
The CRT window was of the conventional four by three aspect ratio (Figure 9, page 82). For reasons to be discussed below (Section 4.3Aii, pages 90-92), the system was arranged such that the extent of the scanning pattern filled only approximately one-half of the total available screen area, viz, the central portion of the window.

The viewing screen phosphor was believed to be the usual mixture of

FIGURE 9 : The overall (external) dimensions of the face of the TV tube and the modified extent of the scanning pattern

(not to scale : all dimensions in mm)

FIG. 9



silver-activated zinc sulphide and silver-activated zinc cadmium sulphide. According to Fink (1963), these phosphors glow with blue and yellow light, respectively, under the impact of high speed electrons. For a monochrome TV viewing screen, the requirement is for a white phosphor with an afterglow time of less than one fiftieth of a second and the highest possible efficiency in converting incident energy into emitted radiation. Consequently, the phosphors are usually mixed, in a fine dispersion, in such proportion that the combination of blue and yellow light produces white light of a very slightly bluish cast. This indeed was the appearance of the TV picture.

When a TV screen is viewed at close range it becomes apparent that the repeated horizontal sweeps of the scanning spot produce a picture that is made up of a number of single, continuous, narrow lines of varying luminance. Each line is usually separated from its neighbours by a blank space; this latter is the part of the CRT phosphor that has not been scanned by the spot, hence it is not emitting light. Little work has apparently been directed towards investigating the effect of this line structure on image legibility. Fink (1957) estimated that adjacent scanning lines cannot ordinarily be distinguished at distances greater than about six times the picture height. A more recent study by Erickson and Hemingway (1970) has indicated that, for subjects with optimum visual acuity, the scanning structure was visible on a TV monitor at a viewing distance of about twelve times the picture height. Erickson and Hemingway (1970) thus concluded that raster-line structure was a relevant parameter and should be considered among the system parameters that affect the viewing of TV screens.

However, in response to this point, it should be stated that in the work reported here the raster-line structure on the TV screen was not visible at the chosen viewing distance (9.7m). Throughout the several experimental studies no remarks relating to this parameter were volunteered from any of the subjects nor could be elicited by direct questioning. In this context it is also worth noting the comment of Shurtleff (1967) who, following a review of the admittedly limited literature concerning the legibility of televised alpha-numeric symbols, made the additional suggestion that the quality of interlace of the scan lines was not a major factor in the accuracy of identification of such characters.

The actual appearance of the TV screen and also the surround field was an important consideration in connection with the establishment of optimum viewing conditions for the experimental work. In this context it was noted that Foxell and Stevens (1955) had undertaken a study to extend the work of Lythgoe (1932), who had previously shown that the surround of a visual task exerted a considerable influence upon, specifically, the visual acuity level recorded. The general conclusions of Foxell and Stevens (1955) were that a surround subtending some 30-40 degrees at the eyes, and having a luminance tending to be rather lower than the immediate background to the test object, would give the best performance under most conditions. A further consideration arose from the means of presentation of the test stimulus. Although the televised picture was to be a relatively simple pattern, it would still be subject to the usual uncertainties associated with the viewing of a CRT window. Nixon (1956) has summarised the factors which control the range of luminance which may be achieved in a TV picture:

(i) Direct illumination of the dark portions of the picture by light from the bright portions. This occurs because the surface of the tube face is curved and the viewing screen itself is translucent. However, to improve picture quality it is now usual to provide a thin continuous film of aluminium as a backing to the phosphor viewing screen; this permits the bombarding electrons to pass without hindrance but, by virtue of its mirror-effect, approximately doubles the light output from the screen. It also prevents ion burn which formerly, in older tubes, produced local reductions of light output from the screen, particularly in the centre.

(ii) Internal reflections in the glass of the tube face. There is typically only partial optical contact between the screen phosphor and the glass of the tube face; thus, instead of a sharp scanning spot there tends to be a diffuse disc with one or more surrounding bright annuli. This halation effect is a result of internal reflection and scatter in the glass. The result is a reduction of picture contrast in closely spaced areas. It may be minimized by lowering the light transmission of the glass of the tube face (typically, to 66% : Nixon 1956), thereby producing a relative attenuation

of any reflected light.

(iii) External illumination. This is a difficult factor to investigate and assess experimentally. However, the total screen reflectance of an aluminized tube is very slightly higher than that of a non-aluminized tube. In addition, it should be noted that it is necessary to provide a flat, thick safety glass screen in front of the tube face in domestic receivers in order to protect the viewer in the event of a tube implosion. This effectively provides a further source of external illumination since light from the brighter parts of the picture can fall on the dark areas by reflection from the safety glass.

A consideration of these factors has led Nixon (1956 : after Hopkinson et al 1951) to make several suggestions with regard to optimum (comfortable) TV viewing conditions; these are of rather academic interest to the domestic viewer but are of particular relevance to the present discussion. The main conclusions may be summarized thus:

(i) That the field of view should be constituted such that the TV screen (A) should have an immediate surround (B) and a general surround (C).

(ii) A should always be brighter than B, which should be brighter than C.

(iii) The solid angular subtense of B should be two or three times the subtense of A.

(iv) The average luminance of the three areas A,B,C should be ideally approximately in the ratio 100:10:1 (although there exists a very wide range about these values which gives satisfactory visual comfort).

It was the intention to present stimuli at substantially reduced contrast levels (vide infra, Section 4.3Av, pages 98-104). In addition, largely for reasons of convenience and practicality (vide infra, Section 4.3Bii, pages 108-109), it was proposed that all experimental work would be undertaken in conditions of good room illumination. In practice it proved problematical to establish those optimum TV viewing conditions as suggested by Nixon (1956 : vide supra). Rather, as a compromise, it was decided that at least an approximately uniform surround field should be presented to the subject whenever he viewed the TV screen in the mirror in front of him.

Consequently, the following arrangements were made with regard to the surround field for the visual task on the TV screen. To shield the distracting peripheral areas of the TV screen from the subject's view, a rigid cardboard mask was constructed. This surround was of a uniform neutral light grey and was affixed directly to the TV screen. An aperture of appropriate dimensions was carefully cut near the

centre of the sheet; this opening was then accurately located over the area of the scanning pattern in the centre of the CRT face (Figures 8 and 10, pages 80 and 89 , respectively). The entire border of the aperture was then fixed to the glass of the tube face using a rubber solution adhesive, such that it abutted directly to the tube face, thereby preventing the casting of a dark shadow around the edge of the viewing window thus formed.

As described below (Section 4.3Biii, pages 109-111) a plane mirror arrangement was used to facilitate the presentation of the stimulus to the subject at the necessary distance of 9.7m. Therefore, a second larger uniform neutral grey general surround was affixed to the actual viewing mirror. Its outer circumference was such that it subtended almost 20 degrees at the subject's eye, this being the maximum size of surround which could be satisfactorily constructed and accommodated in the test room. The border of the central viewing aperture in this general surround was fixed directly to the mirror surface, to prevent the casting of a distracting peripheral shadow. The view of the visual task as seen by the subject, with the immediate and general surround fields, is shown in Figure 10 (page 89).

The electronic control circuitry which governed all aspects of stimulus presentation on the TV viewing screen, and also monitored subjective response, was contained in a ventilated metal instrument cabinet (dimensions : width 485mm, depth 315mm, height 150mm). This cabinet served as a convenient mounting for the TV set itself (Figure 8, page 80), and the system's control panel was mounted conveniently on its front section. A review of the rationale behind the system's electronic control circuitry is provided in Appendix VIII (pages 460-465).

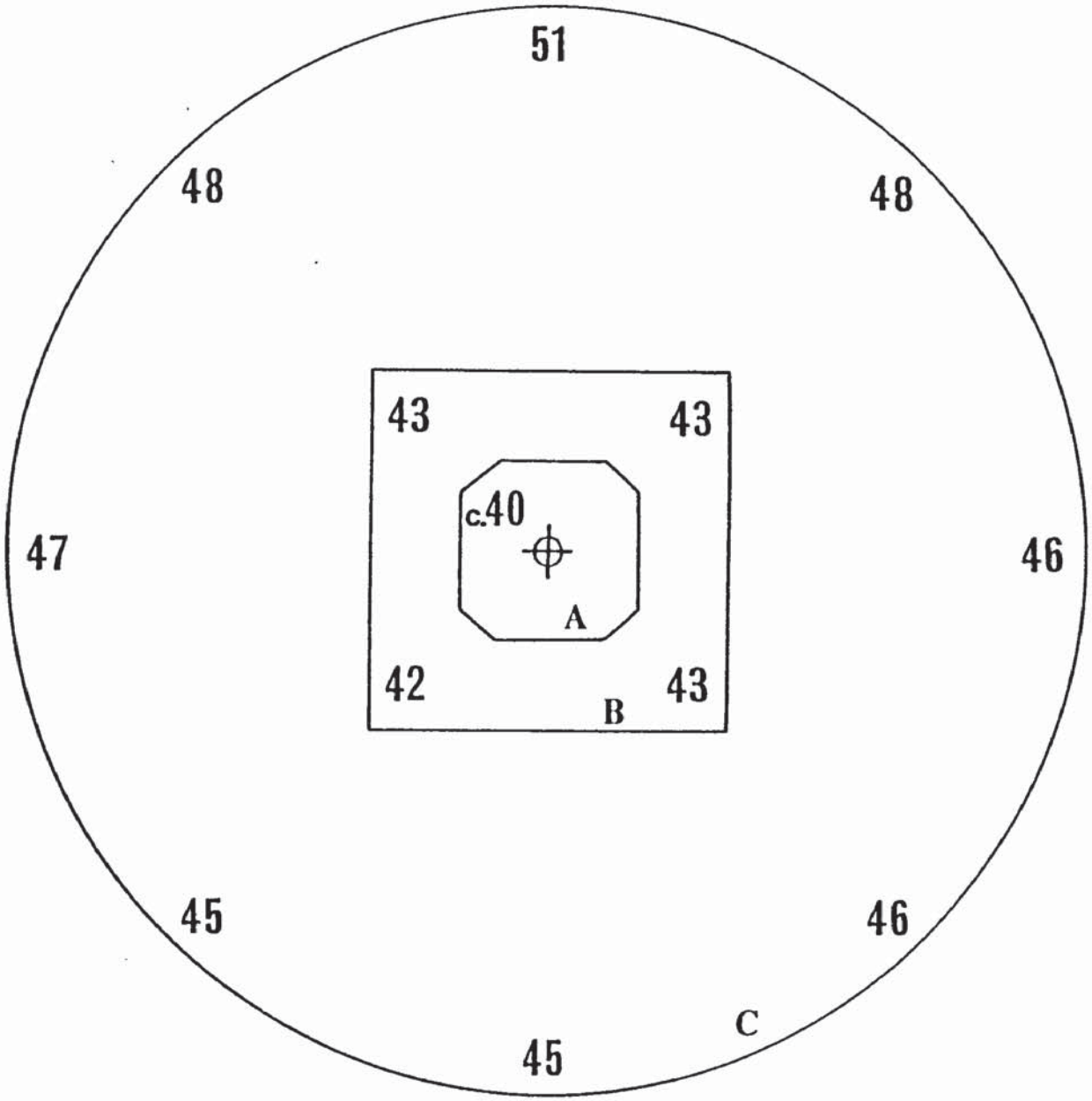
FIGURE 10 : The arrangement (not drawn to scale) and luminance values of the immediate and general surround fields at the visual task, within the direct (straight-ahead) field of view of the subject.

Luminance values (cd m^{-2}) were determined under the visual conditions of ambient illumination in the test room using a Spectra ^{R} "Mini Spot" meter with an angle of acceptance of 1 degree and whose spectral response was matched to the CIE 1931 photopic luminosity function.

Key:

⊹	centration point for alignment of surround fields and line of regard of subject
A	image of TV screen in viewing mirror
B	image of immediate uniform neutral light grey surround (attached to face of TV screen) in viewing mirror
C	general uniform neutral grey surround (attached to viewing mirror) viewed directly

FIG. 10



(test cubicle walls = 50-55)

(cd m^{-2})

The several variables with regard to presentation of the test stimulus will now be described and discussed.

4.3Aii Dimensions of the TV stimuli

As would be expected, when first constructed the entire area of the TV viewing screen was used to present the various sizes of individual broken ring stimuli to the subject. However, after only a few informal trials it was realized that this approach would require some modification.

The first problem centred around the size range of stimuli presented. The width of the break in the smallest ring could only be the equivalent of one or, for enhanced clarity (bearing in mind the transient picture distortion caused by occasional electronic interference - a mild disruption experienced at times with any TV receiver), two scan lines. As with the conventional printed or photo-reproduced Landolt ring character, the limb thickness was to equal the width of the break and the overall size was to be as near as possible five times this dimension. Thus the dimension of the smallest critical detail, i.e., the bottom of the stimulus size range, had a fixed minimum value. Recalling the relationship formalized by Snellen (1862 : Vision, $V = d/D$, where d represents the test distance and D represents the distance at which the test stimulus detail subtends an angle of 1 min arc) any further decrease in angular subtense could only be brought about by increasing the test distance. In the room available for the work the maximum convenient test distance which could be accommodated was 9.7m (the distance from the centre of the TV face to the approximate vertical plane of the subject's eyes).

Even under this condition the critical detail of the smallest stimulus was too large; indeed, the range[+] and selection of stimuli was not discriminating or subtle enough.

In the initial system, each successive stimulus appeared in a randomly determined position within the total viewing screen area. Aside from introducing a small but unwanted element of visual search into the task this also produced a second drawback. If the ring stimulus appeared with its break orientated towards the periphery of the screen and if it was also positioned near the margin of the viewing screen, it was frequently the case that the entire broken side of the stimulus was distorted beyond recognition by the prismatic effect caused by the edge of the glass face, thereby spoiling the visual task.

A third objection, perhaps of rather more of a theoretical nature, was raised from the literature in connection with use of the total screen area. Shurtleff (1967), in a review of reports concerning the legibility of televised alphanumeric symbols, noted that a greater visual size was required for symbols displayed at the edge of the raster than for symbols displayed nearer the screen. This feature was attributed to the slight beam defocussing at the edge of the tube face, apparently a common characteristic of TV displays.

Finally, as a consequence of the curved face of the CRT, the plane through the centre of the screen was 20mm nearer to the subject who was viewing on the tube axis than in the plane through the screen corners.

+ At 9.7m, the clinical equivalents of this original stimulus range were as follows: [6/] 3,6,7.5,13,15,23,27.5,49.

In response to these four points it was decided that the easiest way to circumvent all the problems would be to reduce the extent of the scanning pattern. Consequently the scan raster was electronically contracted such that it only extended across the central portion of the TV screen. Thus a TV picture was produced which was approximately fifty per cent of the usual dimensions. By this procedure a more discriminating range of stimulus sizes were produced at the maximum available test distance (Table 3, pages 93-94), the peripheral distortion and possible beam defocussing problems were both eliminated, and the horizontal distance (as measured along the tube axis) between the planes through the screen centre and the four corners of the reduced screen area was now reduced to only 5mm.

An important point which should be noted here in connection with the TV stimuli is the effect upon legibility of the line construction as opposed to the solid stroke construction of, for example, printed symbols. Shurtleff (1967) has reviewed several studies in this area. He observed that even if it were possible to achieve 'perfect' TV scanning, any resolution of around half a dozen lines or less would produce a loss in accuracy of identification. Results obtained with both idealized and actual TV displays have indicated that the minimally acceptable symbol resolution is in the range of approximately five to twelve lines. Little could be done in this connection with the present system, since the range of stimulus sizes (i.e., the critical detail) was a geometrical progression based upon the smallest practical element, viz, two scan lines. On a more positive note, however, statistical analysis of the data from such studies has shown (Shurtleff 1967) that angular scan line orientation has no significant effect on either accuracy or speed of identification of

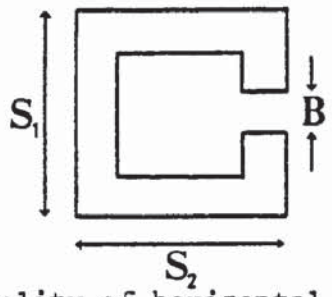
Table 3: Physical dimensions and angular subtense of the broken ring stimuli.

Stimulus No. in Cycle	Orientn. of Ring[a]	Dimension[b] (mm) S_1	S_2	Mean Side	B	Mean Break	Ratio:[c] Side/ Break	Clinical Equivalents[d] Visual Angle (min arc)	Snellen Notatn.
0,8	L, R	4.5	5.5	5.00	1.0	1.00	5.00	0.35	6/ 2.12
	UP, DN	5.5	4.5		1.0				
1,9	L, R	7.0	8.0	7.50	1.5	1.50	5.00	0.53	3.18
	UP, DN	8.0	7.0		1.5				
4	L, R	9.0	10.5	9.75	1.5	1.75	5.57	0.62	3.71
	UP, DN	10.5	9.0		2.0				
5	L, R	13.5	16.0	14.75	3.0	3.25	4.54	1.15	6.89
	UP, DN	16.0	13.5		3.5				
2	L, R	18.5	21.0	19.75	3.5	3.75	5.27	1.32	7.95
	UP, DN	21.0	18.5		4.0				
3	L, R	28.0	30.5	29.25	5.5	5.75	5.09	2.03	12.19
	UP, DN	30.5	28.0		6.0				
6	L, R	37.0	42.5	39.75	7.0	7.75	5.13	2.74	16.43
	UP, DN	42.5	37.0		8.5				
7	L, R	56.5	63.0	59.75	11.0	11.75	5.09	4.15	24.91
	UP, DN	63.0	56.5		12.5				

continued/...

Table 3: continued

a Orientation of a ring:



Note the slight inequality of horizontal and vertical lengths of side; the horizontal length (i.e., as measured along the scan line) was always the larger regardless of whether it contained the break or not. However, this variation could not be appreciated at the viewing distance of 9.7m

b Dimension (mm) as measured directly with calipers at the centre of the glass face of the television screen. Each tabulated value is the mean of twenty repeated measurements made under constant conditions.

c Ratio: ideally, length of side/break = 5.00.

d Clinical equivalents when stimuli viewed at 9.7m. The figures were initially calculated for 6.0m using the relationship:

$$X = T \times \tan 1' \quad \text{(Emsley 1952)}$$

where X represents the linear size of the break (mm), T represents the distance (mm) at which the break subtends 1 min arc at the nodal point of the eye's optical system, and tan 1 min has a value of 2.92×10^{-4}. These calculated values were then extrapolated to the actual test distance utilising the ratio 6.0/9.7, i.e., the multiplication factor 0.6186.

televised symbols. In addition, Shurtleff (1967) observed that the quality of equipment had little effect upon accuracy and speed of identification of televised alphanumeric symbols.

The broken ring stimulus, as displayed on the TV screen (Figure 8, page 80), took on a rather more angular appearance than the conventional form of Landolt ring. It was constructed on a five by five unit matrix, and was thus similar to that angular version of the test symbol as depicted in Figure 3 (page 35) (vide review: Pointer et al 1980a). A square image was much easier to generate than a circular one on the screen of a CRT and consequently produced a more stable picture (Peaston 1977 : personal communication). The break was arranged to appear in the middle of one of the four sides only, viz, on the top, bottom, left or right of the stimulus; aside from such considerations as the 'oblique effect' (review : Appelle 1972), this also made for ease and stability of generation (vide Appendix VIII, pages 460-465).

Eight different sizes of broken ring were presented (Table 3, pages 93 - 94). The two smallest rings were repeated producing a cycle of ten presentations. Whilst the sequence of presentation of each of the ten stimuli was constant in each cycle, it will be appreciated from Table 3 (pages 93 - 94) that there was not a steady progression of angular size from one presentation to the next. This feature, in conjunction with the completely random orientation of the position of the break in each successive presentation, was intentionally designed into the system to facilitate the use of a psychophysical test procedure. The same fixed, mixed size sequence was preserved throughout the entire experimental work, being repeated indefinitely

when the system was switched on.

The stimulus sizes were arranged on the basis of the following geometrical progression (the preferred type of progression : reviews Bennett 1965, Hill 1970):

STIMULUS No. in cycle :	0,8	1,9	4	5	2	3	6	7
DIMENSION RATIO :	1	1.5	2	3	4	6	8	12

4.3Aiii Orientation of the TV stimuli

As outlined in Section 4.3Aii (page 95.), for reasons of televised picture stability and also in deference to the oblique effect, the broken ring stimuli were presented with breaks in the four cardinal directions only, viz, with the break occurring in either the top, bottom, left or right sides of the angular ring.

It was the original intention that the orientation of the stimulus at each presentation would be entirely random, i.e., that the subject would be faced with a four-choice situation each time. When first constructed, however, it was realised that this was not the case; the orientation of successive stimuli was varying in a regular way, i.e., the break was alternately appearing in the horizontal then the vertical limbs of the ring. Such a rudimentary manner of presentation would have to be pointed out to the subjects to ensure validity and comparability of data, and of course restricted the response to a two-choice level. This was clearly unsatisfactory. The particular electronic control system was modified accordingly, and in all the

subsequent work the orientation of the stimuli was entirely random, the subject being presented with a genuine four-choice situation each time that a broken ring appeared on the TV screen.

Ideally, the number of presentations in each of the four orientations over each and every cycle of ten stimuli per cycle should be approximately equal. The results of subsequent validation work with the completed system (discussed in Section 7.4Av, pages 190-192) revealed a machine bias towards presentation of the stimulus with the break uppermost. Unfortunately, there appeared to be no easy way around this problem without a major re-design of the appropriate control electronics (Peaston 1977 : personal communication).

4.3Aiv Position of the TV stimuli within the scanning area

It was not the intention to provide in any way a visual search type of task with the TV system. However, it was felt to be a possibility that repeated presentation of stimuli at the same point in the centre of the TV screen would accentuate the tedious nature of the task being undertaken by the subject. Consequently, the system was arranged so that it was possible to present the stimulus at various positions within the scanning area. This unpredictability of location, whilst enhancing the random nature of stimulus presentation, also aimed to maintain subjective interest in the visual task.

The stimulus could be presented in any one of five possible locations: either in the centre or at a position nearer one of the four corners of the raster. But again it must be stressed that the choice of location at each presentation was entirely random.

4.3Av Level and direction of contrast of the TV stimuli

A flexibility of approach with regard to the level and direction of contrast between stimulus and background was designed into the TV system.

A first requirement was the provision of a selection of contrast levels substantially below one hundred per cent. The incorporation of a six-position switch on the system's control panel permitted the convenient selection of the desired contrast setting. The approximate contrast-per cent‡ range was calculated to be 55%, 40%, 35%, 20%, 10%, 8% (control settings 1 through 6) in the usual glare-free illumination of the test room (Table 4, page 99).

A second desirable feature concerned the direction or type of contrast. Conventionally, this figure-ground relationship is designated:

(a) Positive (+) - light figure on a darker background

(b) Negative (-) - dark figure on a lighter background

The data presented in the literature with regard to the relative legibility of dark and light print (as viewed by normally-sighted individuals) is frequently contradictory and rarely directly comparable. An early study by Ferree and Rand (1930), for example, reported that speed of vision (i.e., the reciprocal of the minimum duration of exposure necessary for correct discrimination of the position of the break in a Landolt broken ring) was

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‡ Contrast - % is defined as: $\frac{(Lmax - Lmin)}{(Lmax + Lmin)} \times 100$, where L = luminance.

Table 4: Central TV Screen Luminance and Contrast - per cent levels.

Control Setting	Luminance[a] (cdm^{-2})		Contrast - %[b]
	L max	L min	
1	42.12	12.22	55.02
2	34.91	13.98	42.81
3	30.10	14.29	35.62
4	27.28	18.19	19.99
5	27.01	22.14	9.91
6	26.85	23.04	7.80

a Luminance (L) as measured under the usual conditions of ambient illumination in the test room. The light meter used as a Spectra^{R} "Mini-Spot" silicon cell spotmeter (manufactured by Photo Research, a Division of Kollmorgen Corporation, California, United States of America). The meter's angle of acceptance was 1 degree and its spectral response was matched to the CIE 1931 photopic luminosity function. It was held in a fixed position some 30 cm in front of the TV screen so as not to cast a shadow over the picture area. All the measurements were taken at the centre of the TV screen when the latter was displaying the largest broken ring, under conditions of first negative contrast (L max), and then of the positive contrast (L min). Each tabulated value is the mean of twenty repeated measurements made under constant conditions.

b Contrast - % is defined as : $\frac{(L\ max - L\ min)}{(L\ max + L\ min)} \times 100.$

faster for a white ring on a black background than vice versa. However, closer analysis of their data (Taylor 1934) has revealed that the time required for the discrimination of detail, after the sensation was once set up, was actually longer for the white test object on the black background than for the reverse situation.

Note should also be made of the phenomenon of irradiation (Duke-Elder 1968), sometimes termed halation. This is frequently mentioned in connection with the legibility of light characters on a darker background (for example, Soar 1952, 1955).

On the whole, it appears that perhaps the most logical conclusion to draw from the several studies of this question is that, although certain investigators may have shown statistically significant differences in legibility between the two directions of contrast, there is probably no difference of significant practical importance, except in some special cases*. This is certainly the tenor of the conclusion drawn by Seibert et al (1959) in connection with televised characters. They found, using a sample group of normally-sighted individuals, that there were negligible differences in accuracy of identification for dark on light versus light on dark symbols, under normal conditions of ambient illumination.

---

* For example, it is frequently reported that partially-sighted persons indicate a preference for positive contrast, the critical detail being more easily discriminated if it appears as a light object against a glare-free darker background (Mehr et al 1973 , Genensky et al 1973, Sloan 1974, Silver and Gill 1979).

FIGURE 11 : The presentation of a broken ring stimulus on the TV screen at maximum contrast - per cent (control setting 1) and in a negative contrast direction (i.e., a level of -55.02%, under the usual conditions of ambient illumination in the test room)

N.B. The Tandberg reel-to-reel magnetic tape recorder on the right hand side of the TV system in Figures 11-13 is present in connection with a future aspect of the experimental work (vide Chapter 8) and is of no relevance to the present discussion of instrumental control settings.

(Vide footnote : Figure 8, page 80)

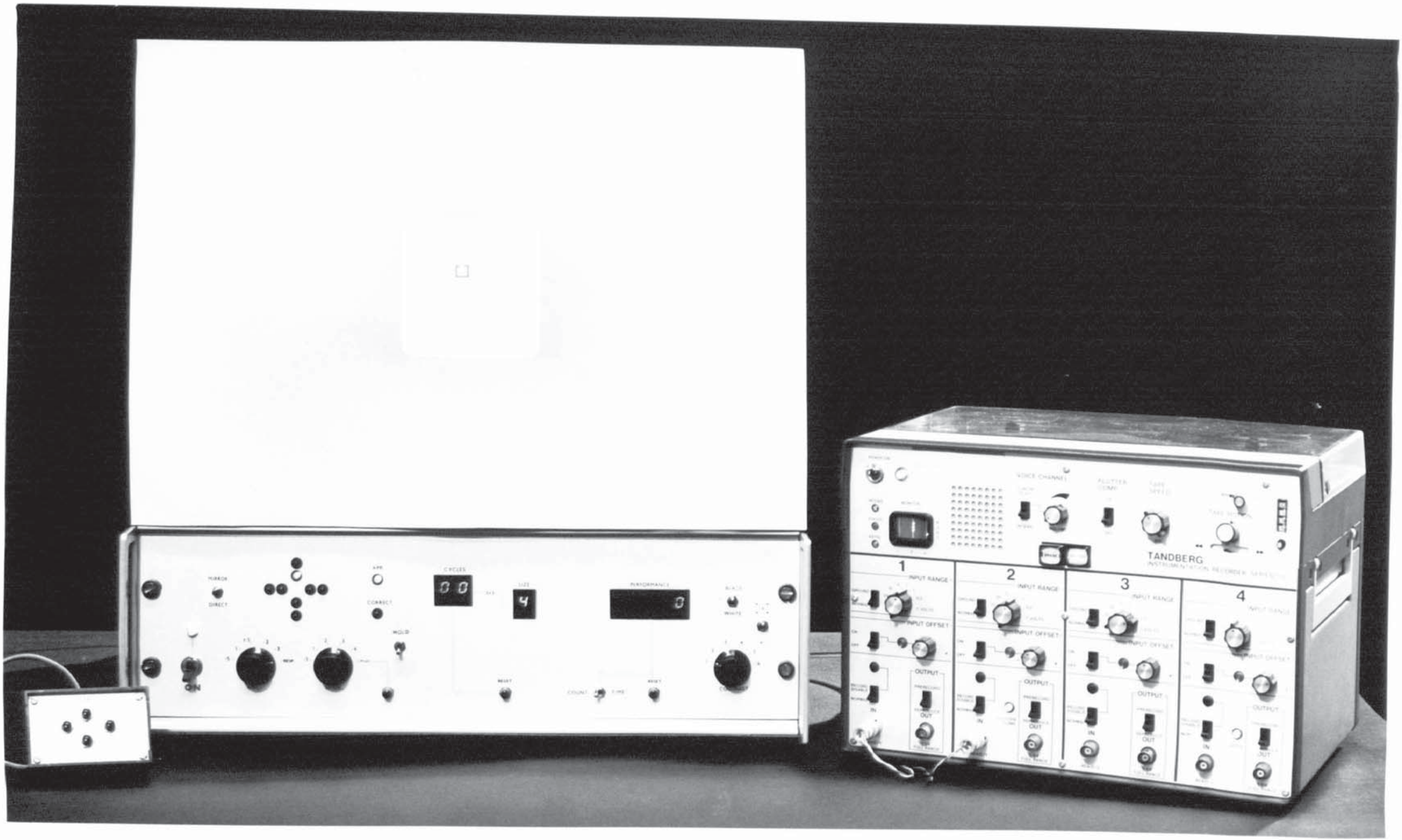

TANDBERG
1
2
3
4
INPUT RANGE
INPUT OFFSET
OUTPUT
IN
OUT
MIRROR
DIRECT
CORRECT
HOLD
CYCLES
SIZE
PERFORMANCE
RESET
ON

FIGURE 12 : The presentation of a broken ring stimulus on the TV screen at lowered contrast-per cent (control setting 3) and in a negative contrast direction (i.e., a level of -35.62%, under the usual conditions of ambient illumination in the test room)

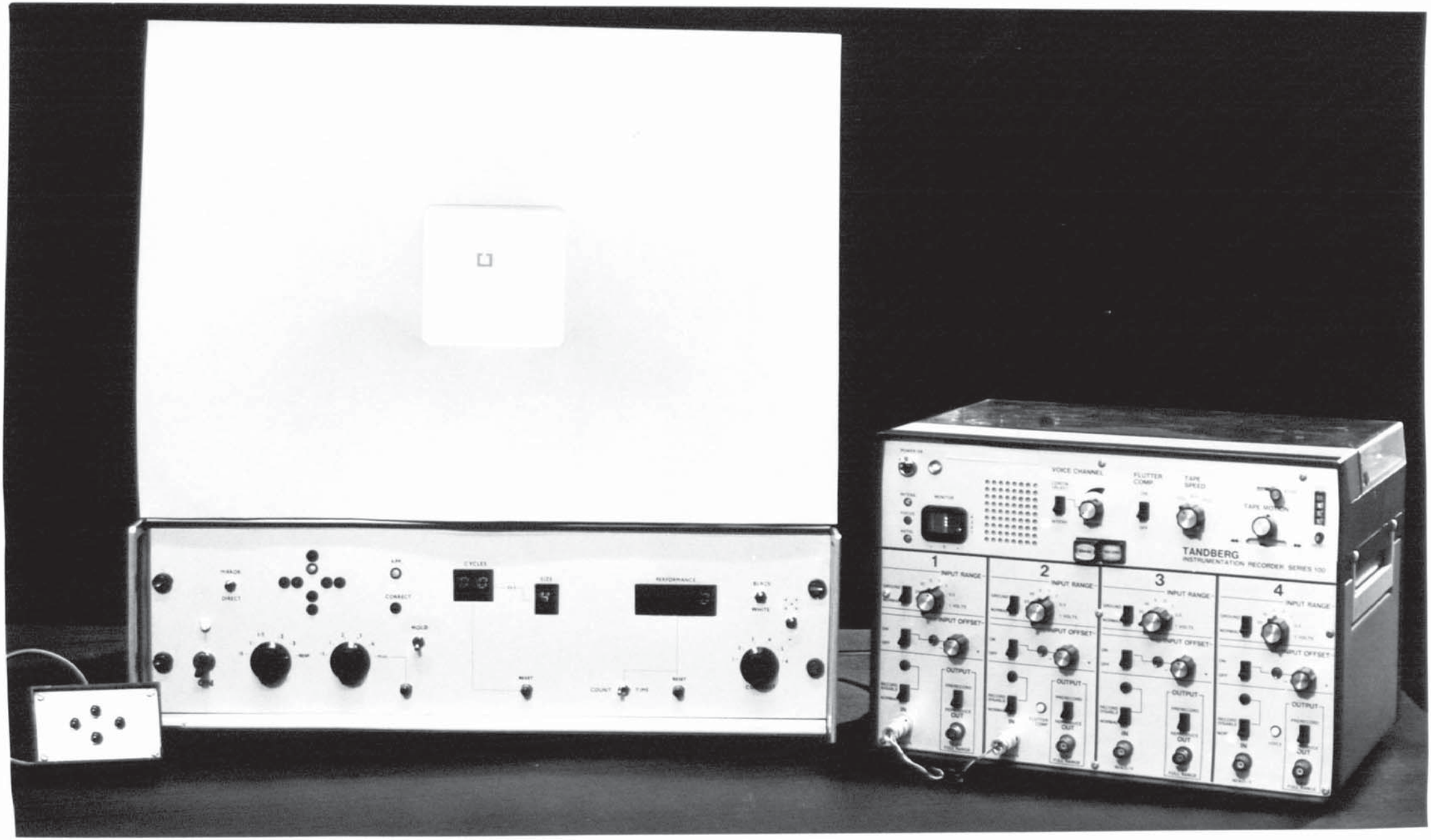
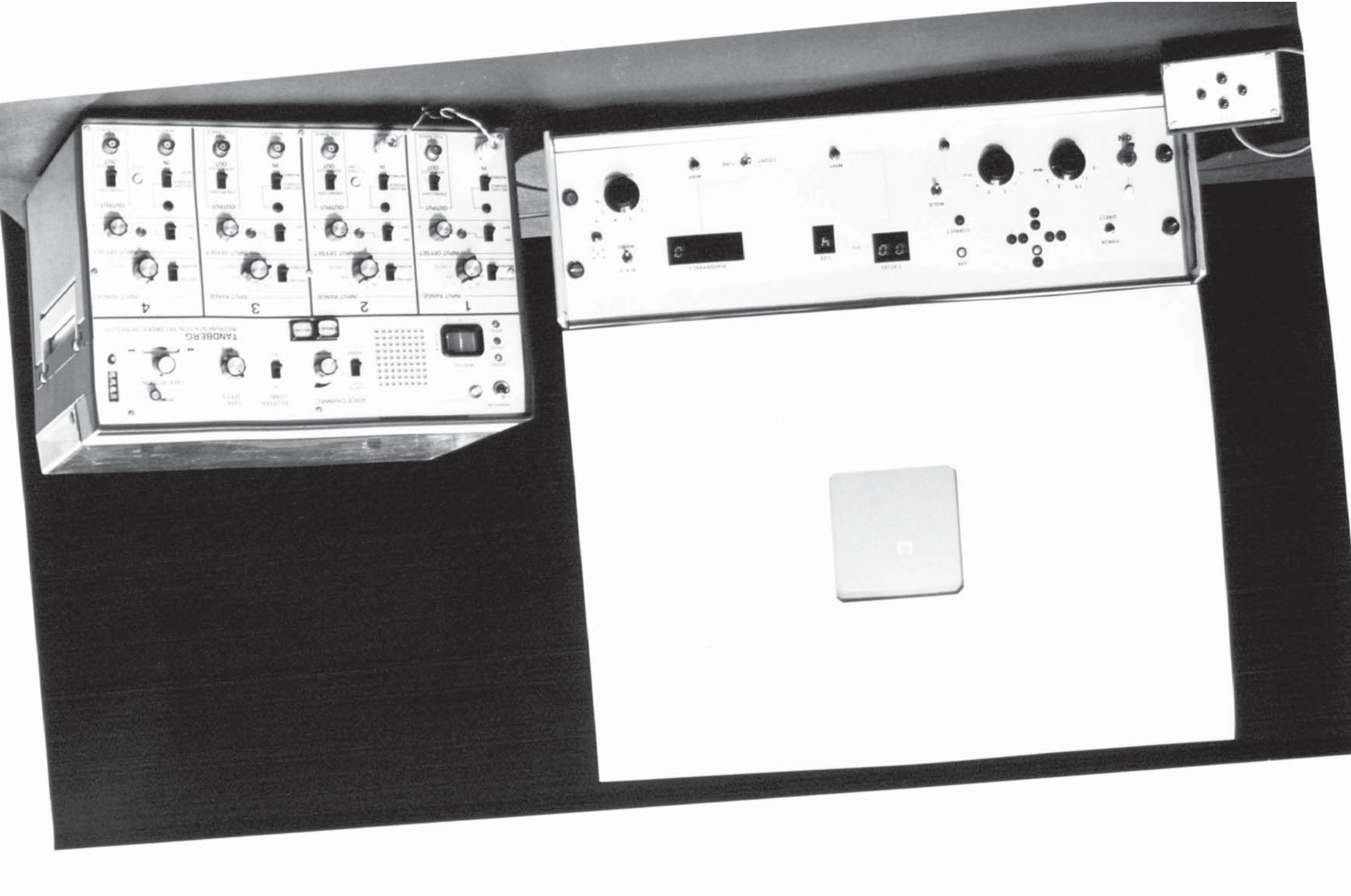

VOICE CHANNEL
FLUTTER COMP
TAPE SPEED
TANDBERG
INSTRUMENTATION RECORDER SERIES 100
1
2
3
4
INPUT RANGE
INPUT OFFSET
OUTPUT

FIGURE 13 : The presentation of a broken ring stimulus on the TV screen at lowered contrast-per cent (control setting 3) and in a positive contrast direction (i.e., a level of + 35.62%, under the usual conditions of ambient illumination in the test room)


TANDBERG

With such inconclusive guidance from the literature, it was decided to incorporate a control which would permit a rapid switch to be made between positive and negative directions of contrast; all other aspects of the stimulus presentation, including level of contrast and physical dimensions, would remain unaltered. A study could then be undertaken to investigate the relative performance under the two stimulus conditions (vide Section 6.1B, pages 146-148).

Figures 11, 12 and 13 (pages 101-103)illustrate three different combinations of level and direction of contrast control settings, to demonstrate the flexibility of the TV system.

4.3Avi Presentation and interval times

Consideration of the studies of Fry and Enoch (1959) and Vasa (1960), and the comments of Fry (1962), clarified certain of the temporal aspects of an automated stimulus presentation system. These studies, discussed in Section 3.2C (pages 59 - 61) recommended:

(i) A stimulus presentation time of 2-3s. To obtain the best indication of a subject's performance, the presentation time must strike a balance between being too short and thereby often producing anxiety, and being too long giving rise to boredom.

(ii) An interval between each presentation. This was recognized as an important resting time between responses, allowing the subject

Table 5: Ranges of Available Presentation and Interval Times.

Control Setting	Presentation Times(s)[a]	Control Setting	Interval Time(s)[a]
0.5	0.76	0.5	0.54
1	1.56	1	0.99
1.5	2.22	2	1.87
2	2.92	3	2.65
3	3.94	6	4.71

a Presentation and interval times were all measured within the period 30 to 90 minutes after the TV system was turned on, i.e., at a time when all components should be at their optimum operating level and temperature. In a data recording arrangement which was a precursor of the full system described in Chapter 8, a thermal printer was interfaced directly to the relevant circuitry of the TV system. Thus the differing voltage levels corresponding to TV stimulus on/off screen produced deflections of a thermal pen in contact with a moving calibrated chart roll of heat sensitive paper. Knowledge of the chart time-base then permitted the ready calculation of presentation and interval times. Each tabluated value is the mean of one hundred repeated measurements made under constant conditions.

to prepare for the onset of the next stimulus.

To permit maximum flexibility in use, two selector controls were provided on the control panel so that a choice of five pre-determined times for both stimulus presentation and the interval were available in the resulting TV system (Table 5, page 105).

In practice, the settings used for the two time periods in the experimental work were something of a compromise between theoretical ideals and practical limitations. Initial trials seemed to indicate settings 1.5 or 2 as providing suitable stimulus presentation times. All responses had to be manually recorded by the person in control of the experimental sessions (in all cases this was the present author). The time taken to monitor, assess and record the response consequently dictated the interval time. In the first two studies, concerned with validation of the TV system (vide Sections 6.1 and 6.2, commencing pages 144 and 148 , respectively) the interval time was setting 2. In all subsequent work (vide Sections 6.3 and 8.1, commencing pages 151 and 203 , respectively) , when a specific ocular excursion was undertaken immediately prior to each stimulus presentation, the interval time was necessarily extended slightly to setting 3.

4.3B A Physical Description of the Test Situation

4.3Bi The test room

All the experimental work with the TV system took place in one

FIGURE 14 : Ground plan of the test room (drawn to scale)

Key:

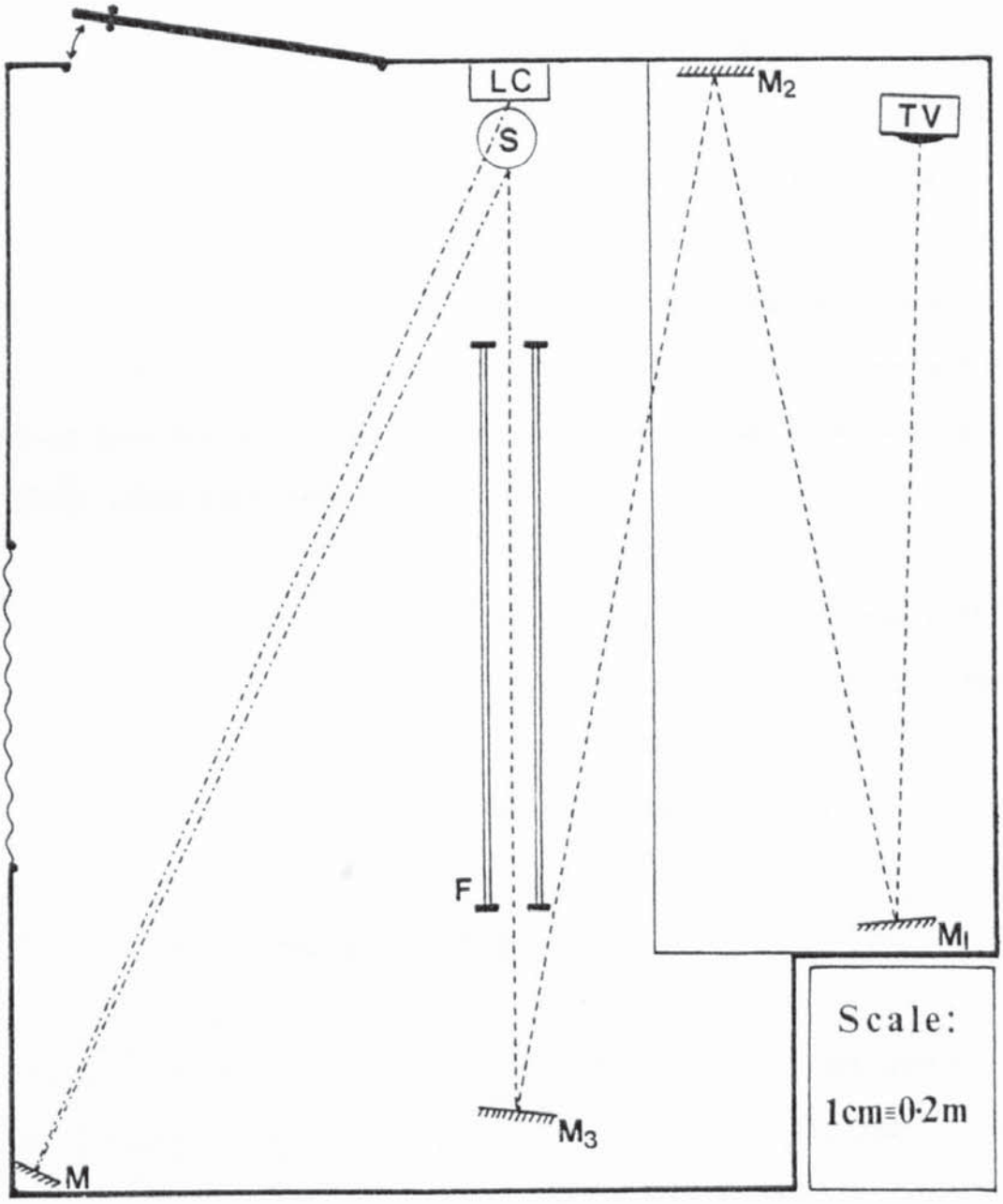
F	location of the twin parallel fluorescent lighting tubes, suspended 3.25m above floor level in a matt white open trough fixture
LC	Landolt chart
M	plane mirror
S	volunteer experimental subject
TV	TV system

Linear distances:

TV ⟶ S (via M_1, M_2, M_3) = 9.7m

LC ⟶ S (via M) = 6.0m

FIG. 14



room. In addition, the screening procedure for prospective subjects, and the refraction, visual acuity assessment and soft contact lens fitting of chosen persons, was all undertaken in this same room.

A ground plan detailing the layout of the test room is provided (Figure 14, page 107). A bench, with closed cupboard space beneath, ran down the greater length of one side of the room; this served as a useful podium for the TV system and the other pieces of equipment used in the experimental work. The bench top was of dark brown stained wood, but the recessed cupboard doors below were of a much lighter brown. On the opposite side of the test room a narrow door space, closed with a heavy black curtain with a fixed pelmet and a weighted hem, allowed easy access to the adjoining, and usually darkened, instrument room.

Aside from these two permanent fittings, the majority of the rest of the test room was of a uniformly lighter decoration. The four walls and ceiling had been emulsioned with matt off-white paint, and the floor was of light grey and brown flecked vinyl tiles.

4.3Bii The test room illumination

In contrast to, for example, the relevant work of Fry and Enoch (1959) and Vasa (1960) described earlier (Section 3.2C, page 57), all the experimental work to be described here was undertaken in conditions of good room illumination. Aside from facilitating the overall administration of the test procedure (most especially in connection with soft contact lens wear), it also obviated the need for dark adaptation of each subject prior to

testing, thereby enabling a quicker turn-around between subjects in a test session. Testing in the light was felt also to be more representative of the usual 'everyday' conditions of viewing. Certainly Appendix A of British Standard B.S. 4274 : 1968 : "Test Charts for Determining Distance Visual Acuity" has strongly recommended the recording of visual acuity under good general conditions of room illumination; this included the suggestions that the use of subsidiary lighting and where possible light-toneddecorations might be of benefit.

The ambient illumination was from a wholly artificial source, being provided by two centrally located parallel 65/80 watt "Industrial White 35" 1.5m fluorescent tubes. They were mounted in a matt white open trough unit suspended approximately 3.25m above floor level in the centre of the room. As already stated (Section 4.3Ai, pages 87-89) the TV screen itself was not directly shielded from the ambient light.

4.3Biii The test distance

The test distance, i.e., the distance from the centre of the modified scanning area at the centre of the TV screen to the approximate vertical plane of the subject's eyes, was 9.7m.

In conjunction with considerations of the desirable range of angular subtense of the TV stimuli (Section 4.3Aii, pages 90 - 91, 93 - 94), this was the maximum convenient test distance which could be accommodated in the test room. The distance was maintained constant since:

(i) Once the equipment had been set-up and aligned

it was not moved between experimental sessions.

(ii) The approximate vertical plane of the subject's eyes was fixed, within limits of a centimetre or so, by the simple expedient of having the subject lightly rest the back of his head (in a vertical position) against a protruding soft yet resilient head rest attached to the back of the hydraulic consulting room chair upon which he was seated. Over a typical test session of approximately one hour this was an instruction readily complied with by all subjects; with the provision of breaks between runs and ample vertical adjustment of the head rest, no problems associated with neck pains or abnormal head postures arose.

In the restricted space of the test room, the stated test distance was achieved by the use of three plane mirrors, suitably angled (Figure 14, page 107). The objective was to present to the subject a clear uninterrupted view of the stimulus on the TV screen, while at the same time:

(i) Preventing him from being able to obtain either a direct or a foreshortened view of the TV screen.

(ii) Shielding him from any distractions provided by the LEDs and score counter on the TV system's control panel.

It was conceivable that a slight amount of distortion would be produced by the use of the mirrors, largely as a consequence of a possible deviation from exact on-axis viewing conditions. However, Seibert et al (1959) have found that a viewing angle of up to 19 degrees from the normal (on-axis) line of regard does not decrease the accuracy of identification of televised characters. (The critical angle at which some loss in accuracy of identification did occur was shown to lie somewhere between 19 and 38 degrees from the normal line of sight.) As the glass and silvering of the mirrors was of good quality, this viewing arrangement was felt to be satisfactory.

As previously noted (Section 4.3Bi, page 108), acuity assessment with the conventional internally illuminated Landolt ring test chart (complying to B.S. 4274 : 1968) was undertaken in the same test room as the experimental work with the TV system. The test cabinet was mounted on the wall above the subject's head (Figure 14, page 107), in the usual manner of the optometric consulting room. By merely averting his gaze to the right-hand corner of the room the subject could view, at exactly 3m, a free-standing plane mirror which thus presented the Landolt rings at 6m, the standard test distance.

4.3C The Method of Operation of the TV System and Data Generation

In the usual method of operation, the random (in terms of orientation

and position within the scanning area) sequence (in terms of the repeating cycle of ten sizes) of single four-position broken ring test stimuli was presented to the subject at the viewing distance of 9.7m. The subject was required to indicate the position where he perceived the break to occur in each stimulus by merely pressing one of the four buttons on a hand control box (Figure 8, page 80).

A cassette tape recorder was used to instruct each subject in the experimental procedure. The delivery of tape recorded instructions had been previously suggested by Crossman et al (1970), and indeed had been used successfully by, for example, Erickson and Hemingway (1970). It certainly made the induction procedure more efficient, and had the advantage of removing any unintentional bias or emphasis from the instructions given to different subjects as a consequence of altered inflections in the voice of the person instructing the subject (in all cases this was the present author).

In the instructions the need for a prompt response to each stimulus was stated, guessing being allowed in the event of any uncertainty, but it was stressed that only one response to each visual stimulus was permitted. The initial period of instruction, and the trial runs allowed before every session of data collection, served to steady the state of light adaptation of the subject. Normal pupil sizes were used, essentially for reasons of convenience and practicality, especially in connection with the specific ocular excursion subsequently introduced into the work. In a similar way to blink rate (previously discussed : Section 3.3, page 62), features such as pupillary movement and size (reviewed by Goldwater 1972) and palpebral fissure size (Anon 1962b) have been reported to vary in a complex manner with

the nature or difficulty of the visual task being undertaken.

The investigator noted the actual position of the break in each stimulus presented by direct observation. He was able then to record the correctness (or not) of the subject's subsequent response in an accurate manner since, when the subject depressed one of the four buttons on the hand control box, one of four corresponding red lights became illuminated on the front of the TV system's control panel (screened from the subject's view, as Section 4.3Biii, page 111, has explained).

Largely as a consequence of restrictions on finance and available time of expert technical assistance, the logical sequela of an automated stimulus presentation procedure, viz, an automated response recording system, was not available for this work. Consequently, manual recording of this information was necessitated. Special charts were designed (Appendix V : Figure 27, page 427), and for each stimulus and response the following information was recorded:

(i) The orientation of the stimulus, as presented to the subject in the mirror.

(ii) The orientation and correctness (or not) of his response.

It should be noted that a correct response was registered only if the appropriate button on the hand control box was depressed whilst the broken ring stimulus remained on the TV screen. In the event of any uncertainty, the subject was encouraged to guess, so that for

every stimulus presented there was always a corresponding response: the psychophysical method of constant stimuli with the forced choice response technique.

It was decided, largely on the basis of numerical convenience, that a single run with the TV system would be composed of one hundred stimulus presentations, i.e., ten cycles or ten presentations of each of the ten (eight plus two repetitions) variously-sized broken ring stimuli. Reference to the recording chart (Appendix V : Figure 27, page 427) will indicate that it was then a simple matter of counting along rows to obtain a column of raw scores representing the total number of correct responses for each size of ring. These raw data scores then underwent a mathematical transformation which corrected the scores for the guessing element involved in their generation. This procedure and the rationale behind it is founded on work involving a mechanical method of presenting broken rings to a subject carried out by Prince and Fry (1956, 1958) : the procedure is described in Appendix V (pages 426-430).

CHAPTER 5

THE DESIGN OF THE EXPERIMENTAL STUDIES

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5.1 Introduction : The Scope of the Research Work

It was the intention that the experimental work undertaken with the TV system should encompass two successive areas of study.

(i) An assessment of the TV system's capability as a research tool for the investigation of visual performance:

(a) The optimization of certain of the TV system's variables with regard to the presentation of the stimulus and the monitoring of the subjective response.

(b) An investigation of the degree of repeatability of the data generated by subjects using the TV system.

(c) A refinement to the experimental approach - The incorporation of a specific ocular excursion into the experimental operating procedure.

(ii) The utilization of the TV system (in the manner evolved from the optimization and validation work) in a fourth study:

(d) The visual performance of subjects adapting to soft contact lens wear.

The rationale of the design of the several experimental studies will now be discussed.

5.2 The Assessment of the TV System's Capability as a Research Tool for the Investigation of Visual Performance

5.2A The Optimization of Certain of the TV System's Variables with regard to the Presentation of the Stimulus and the Monitoring of the Subjective Response

The TV system was constructed with a view to maximum flexibility of approach (vide Section 4.3Ai-vi, page 81 et seq.). Consequently, several settings were available for both the duration of stimulus presentation and the interval, and also for the level and direction of constrast of the stimuli.

It has already been stated (Section 4.3Avi, page 106), that a choice of settings for both the stimulus presentation and the interval times had been decided upon before the present author became involved in work with the TV system. Subsequent informal trials by the present author indicated that, of the range available, setting 1.5 (2.22s : Table 5, page 105) appeared to represent a suitable presentation time, both from a theoretical and a practical point of view. The manual recording of subjective responses dictated the selection of setting 2 (1.87s) for the interval period.

The selection of control settings for the two aspects of stimulus

contrast, viz, level and direction, posed more of a problem. As Section 4.3Av (page 104) has described, while the literature strongly recommended the investigation of vision at contrast levels substantially below the frequently-encountered level of almost one hundred per cent, it offered inconclusive guidance as to whether positive or negative contrast between stimulus and background was to be preferred. Consequently, with the present TV system an early investigation was indicated of relative subjective performance under the six available contrast levels, and at the two alternative figure-ground relationships.

Such an investigation would serve a dual purpose. Firstly, it would generate a useful file of data using the TV system : a formal experimental design could be devised, potential experimental subjects could be screened for suitability before participation, and all work would be carried out under conditions of strict control and supervision. The data thus amassed would then be available for a full analysis. Secondly, the experience of operation afforded by such an investigation would provide an opportunity for studying the operating technique and, in the light of the observations over the duration of the study, of altering or refining the approach in subsequent work.

Turning now to specific aspects of experimental design, an early decision was made, when taking into account both the time and clinical space available for the work and the number of potential subjects, that it would be most suitable to have a conveniently large group of subjects undertaking the minimum of repeated runs, rather than the reverse situation of a few subjects undertaking several repeated runs. The collection of data from a relatively large and diverse range of

sources could prove to be a more demanding but more valid trial of the TV system. At this time it was decided also that subjects participating in this first study would do so under binocular viewing conditions, wearing their best spectacle correction in the form of trial case lenses in the usual spectacle plane (approximately 12mm). (It should be noted here that in all subsequent work with the TV system subjects were rendered monocular, as only on this basis could the separate performance of the two eyes of an individual be assessed.) As this initial study was to be, in part, a data-gathering exercise, the decision to allow the use of the two eyes was felt to be justified on the grounds of ease of explanation and operation. In addition, it would obviate any queries in connection with the use of dominant or preferred eyes, and such anomalies as inequality of acuity or refraction.

The two factors of stimulus contrast, in the context of work with the TV system, may be stated formally thus:

Factor A : direction of contrast = 2 levels

Factor B : level of contrast = 6 levels

i.e., total $\left[A \times B \right]$ = 12 experimental treatment levels.

The minimum number of repeated runs (i.e., two) would be undertaken by each subject at each treatment level, so therefore a total of twenty-four runs per subject would be required. Previous informal trials had indicated that one run of one hundred stimulus presentations (i.e., ten cycles of the ten variously-sized broken rings) took in the region of five minutes to complete, at the previously stated settings of presentation and interval times. Thus, twelve runs could

comfortably be accommodated in a test session of one hour's duration, and this was generally felt to be a reasonable length of time for engaging and maintaining a subject's attention. Consequently, two data collection visits per subject would be required. It was decided to repeat runs at any given treatment level in a single visit, so the contrast levels were grouped into two divisions : levels 1, 3, 5 would be tested at the first visit, and levels 2, 4, 6 at the second visit. Table 6 (page 120) details the chosen sequence of runs to be undertaken at each visit : run numbers 1 to 12 at the first session, and numbers 13 to 24 at the second. The order was intentionally random as regards contrast-per cent level, but was to be regular with regard to contrast direction, the runs being alternately at negative and then at positive contrast.

TABLE 6 : Study No. 1 - The sequence of runs

		CONTRAST LEVEL					
		1	2	3	4	5	6
CONTRAST TYPE	-	1, 7	13,19	3, 9	15,21	5,11	17,23
	+	4,10	16,22	6,12	18,24	2, 8	14,20

To facilitate planning and to prompt each subject's memory, the two visits should be arranged both to be at the same time of day, exactly one week apart. (It was anticipated that the majority of subjects would be University students, who would thus have established periods of free time each week as per their formal lecture timetable; therefore

it should prove possible to arrange firm appointment times several weeks in advance.) A small financial reward would be paid to each subject on successful completion of both data collection attendances.

As discussed in Section 4.3C (page 112), at the commencement of both of the experimental sessions instructions on the operating technique would be given to each subject via a cassette tape recorder. These pre-recorded instructions would advise the subject that requests for brief rests between runs would be permitted; also, that at the end of each session he would be required to indicate verbally whether he had any subjective preference (manifested by, for example, a greater confidence of response) for dark rings presented on a lighter background or for the reverse situation of light rings on a darker background, irrespective of the contrast level.

In this, as in all subsequent studies, several trial runs would be undertaken to ensure subjective familiarity with the operating technique before the commencement of data collection. It should be noted at this point that, in all work with the TV system, each run of one hundred stimuli commenced each time at the same point in the repeating cycle of ten (i.e., eight plus two repetitions) variously-sized broken rings, viz, with the ring arbitrarily designated as stimulus number 0 (vide Table 3, pages 93 - 94).

5.2B An Investigation of the Degree of Repeatability of the Data Generated by Subjects Using the TV System

An important second stage in this validation work, having investigated

certain of the TV system's control settings, would be to assess the degree of repeatability of subjective responses to the televised stimuli. This work could use a smaller number of subjects than the first study, but with each subject undertaking a greater number of repeated runs. All work should be undertaken at constant settings of the controls of the TV system and under uniform experimental conditions. Such a study would also provide the opportunity to assess whether there is any evidence of the existence of learning or fatigue effects. Thirdly, it would enable a decision to be reached with regard to the optimum number of repeated runs necessary to generate accurate and reliable results.

A group of about five subjects should be a reasonable size for this repeatability study. All results would be obtained under monocular conditions, the subject wearing the best spectacle correction before his dominant eye and achieving a subjectively-determined acuity of at least $^{6}/_{4}$ on the Landolt chart at 6m. All subjects would be naïve observers, having had no previous experience of operation of the TV system.

Each of the five subjects would be allotted, on a random basis, to a particular day (Monday to Friday) in the week of the study. On this day he would be required to attend for two data collection visits : at 9.00 a.m. for his first session and at 4.00 p.m. for the second. At each session, ten runs (comprising, as usual, one hundred stimuli each) would be undertaken. Each session should be of approximately fifty minutes duration, on the basis of previous work.

The experimental approach and the control settings of the TV system

would be as in the first study, with the exception that a single level and direction of stimulus contrast would be chosen, on the basis of the results of the analysis of the previous work. Instructions relating to the operating procedure would be delivered via a cassette tape recorder, and ample trial runs would be undertaken before any data collection commenced. The instructions would again advise the subject that requests for brief rests between runs would be permitted.

5.2C The Incorporation of a Specific Ocular Excursion into the Operating Procedure

In an attempt to more accurately simulate normal viewing conditions, it was decided that a third study should investigate the possible effects of incorporating a specific eye movement into the operating procedure. A review of the relevant literature was indicated to ascertain the precise details concerning the most suitable form that this movement should take.

Voluntary movements of the eyes, either of free will, or on command, or on changing the fixation point from one object to another, are effected binocularly by saccades. 'Saccade' was the name originally given to the rapid movements between fixation-pauses that occur in reading, but it is now applied more generally to the conjugate shifts of gaze from one fixation point to another.

The mechanics of the saccade were first formally investigated by Westheimer (1954), who found a reaction time of 120 - 180 ms, after which both eyes move simultaneously. The movement develops quickly,

building up to a peak velocity and then slowly subsiding (Westheimer 1954, Hyde 1959); at the end of the excursion the target is slightly overshot and regained by minute oscillations with an average angular excursion of 10-15 s arc (seconds of arc). Saccadic movements are extremely rapid, the maximum velocity attained varying with the magnitude of the saccade (the greater the amplitude of the movement the higher the speed). Westheimer (1954) found a velocity of 300 degrees of arc s^{-1} for a 10 degree excursion and 500 degrees of arc s^{-1} for a 30 degree movement, while Hyde (1959) found a maximum velocity of 830 degrees of arc s^{-1} when the amplitude of the movement reached 90 degrees. A 10 degree saccade can occur within 45 ms after its beginning (Robinson 1964).

Duke-Elder (1973) states that horizontal movements are more rapid than vertical movements, although Yarbus (1967) claims that the duration of oblique saccades is indistinguishable from the duration of horizontal and vertical saccades of the same amplitude. In all cases the movement is most rapid if attention is concentrated on the final fixation point. Brockhurst and Lion (1951) have reported that eye movements from a peripheral to a central fixation point were faster than for movements in the reverse direction; however, from their data, for an angular displacement of 15 degrees this difference in velocity would be relatively small.

It is generally thought that during the saccadic movements vision is inhibited (Ditchburn 1955), but this is difficult to verify since the visual stimulus may still exist and remain below the threshold. It is possible that this inhibition may be due to the movement of the entire visual pattern during the saccade rather than to the movement of the eye (MacKay 1970, Mitrani et al 1971).

When the eyes move from one fixation point to another, the relationships of the trajectories of the two eyes are not necessarily identical and conjugate as is implicit in Hering's law, although the final termination is conjugate and exact. This has been credited to the differences in the time-relations in the activity of the antagonistic muscle pairs (Fuchs and Luschei 1970, Robinson 1970).

Lancaster (1941) has claimed that 99% of all human eye movements are within 15 degrees of the primary position. More recently Bahill et al (1975) have stated that most naturally occurring human saccades have magnitudes of 15 degrees or less. This citing in the literature of a magnitude of 15 degrees in connection with saccadic amplitudes prompted the selection of this particular angular displacement for the projected work incorporating a specific ocular excursion. Also of significance in connection with this choice was the fact that Bahill and Stark (1975 : citing McFarland et al 1942) have reported that fatigue studies have failed to show any effects of fatigue for, specifically, 15 degree saccades.

Having decided upon the amplitude of the saccade, the next obvious experimental point would be to select a direction for this eye movement. In order to fully assess the effects of an ocular excursion in the horizontal, vertical and oblique meridians, it was decided that the opportunity would be taken to investigate eight separate directions of gaze. Consequently, eight fixation points (one at each of the four cardinal points and one in each of the four oblique positions) should be located at regular 45 degree intervals on the large uniform neutral grey general surround attached to the viewing mirror fixated by the subject (Figure 15, page 126). Each fixation point should lie

FIGURE 15 : The locations of the eight red peripheral fixation points on the uniform neutral grey general surround field at the visual task, as viewed by the subject (not to scale)

The viewing aperture is 2.50 m from the subject (S), and on the same level as his eye:

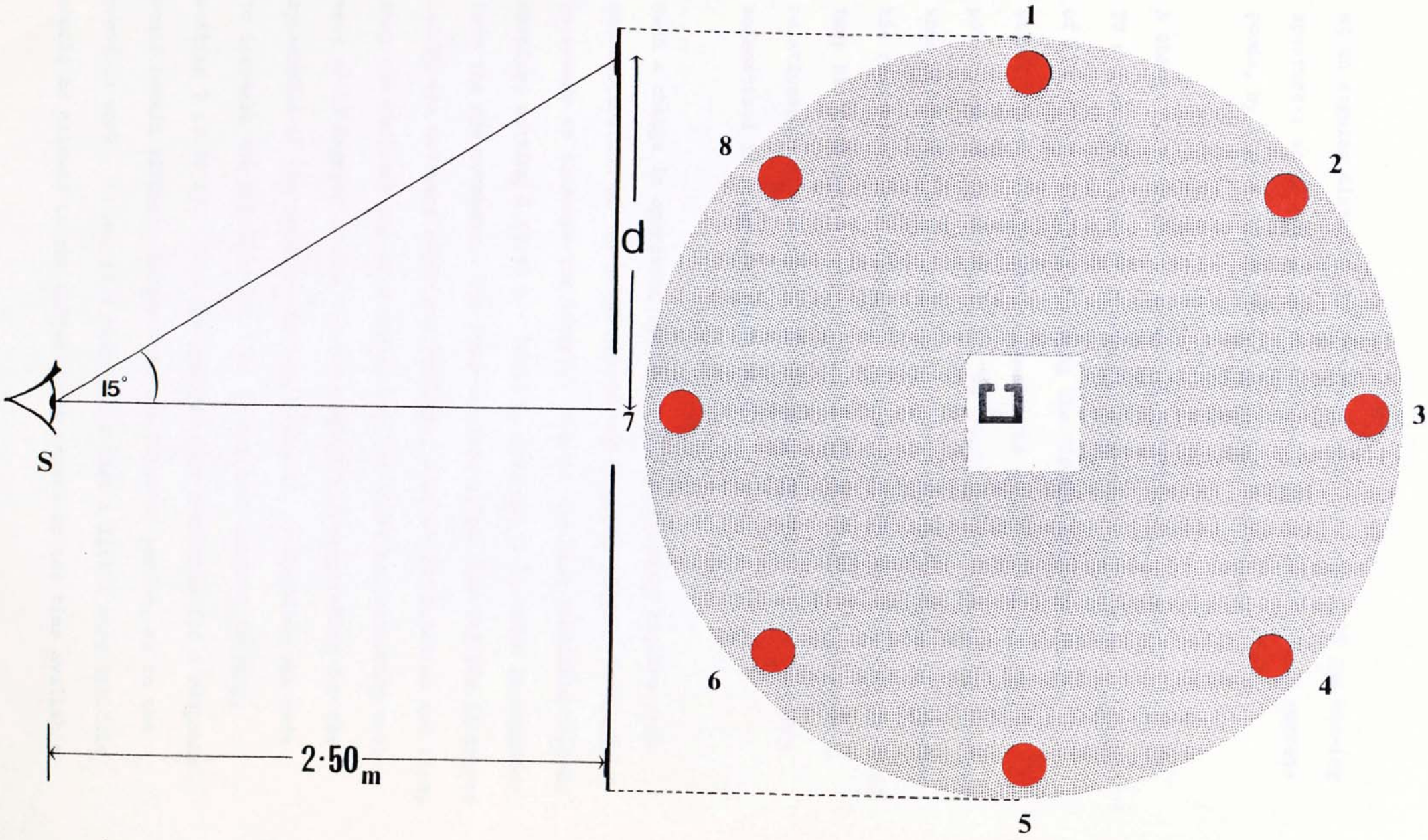
$$\text{Tan } 15^{\circ} = {}^{d}/_{2.50}$$

$$\therefore\ d = 0.2679 \times 2.50$$

$$\text{i.e., } 0.6699 \approx 0.67\text{m.}$$

Thus the desired angular displacement of 15 degrees from the centre of the aperture corresponds to a linear distance of 0.67 m.

FIG. 15



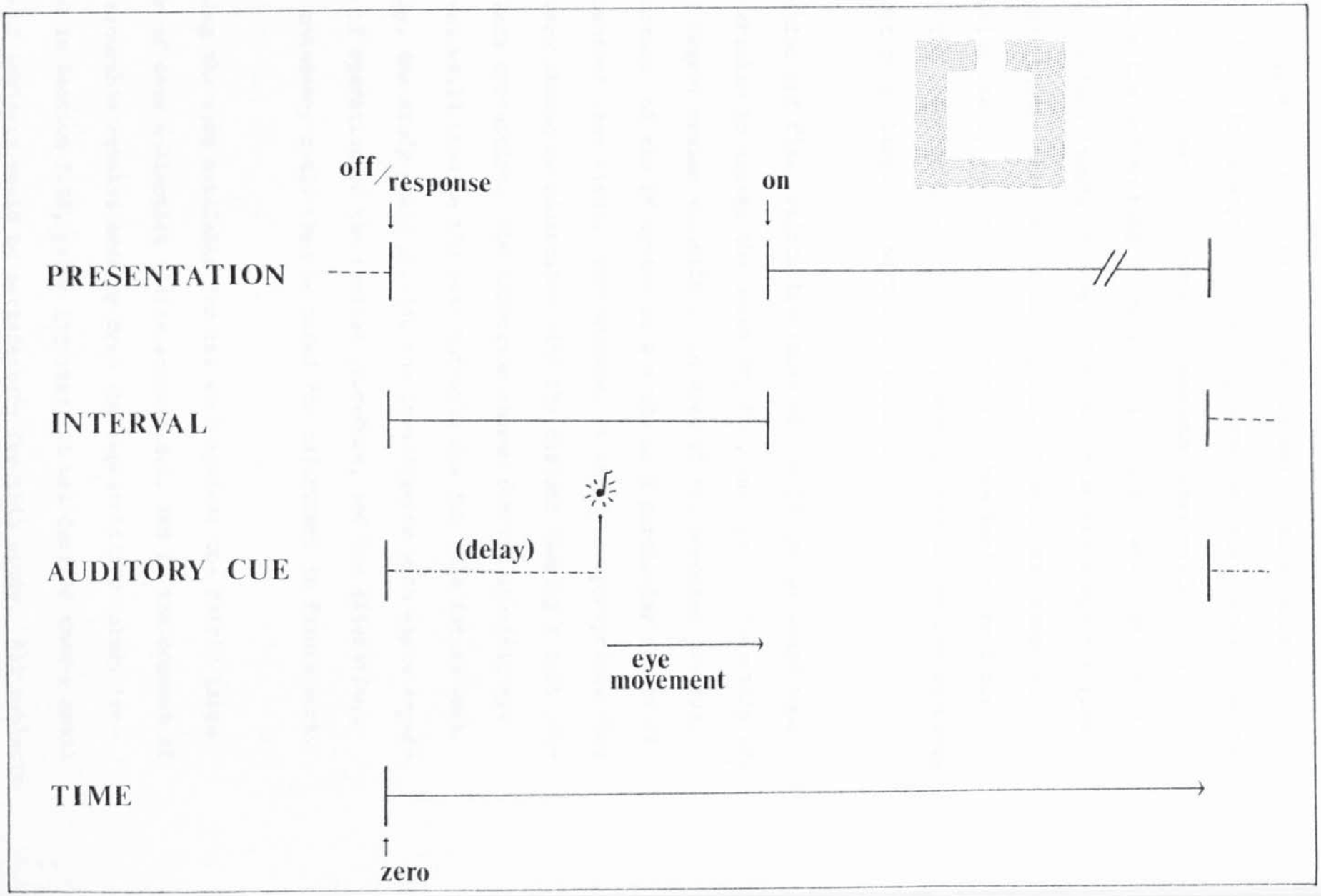
at an angular distance of 15 degrees from the centre of the viewing aperture : as Figure 15 shows, such an angular displacement corresponds, by simple trigonometry, to a linear distance of 0.67m.

A change in experimental operating technique for subjects using the TV system would then be introduced with this third study. Instead of the subject steadily fixating the viewing aperture whether a stimulus was being presented or not, he would now be fixating a point some 15 degrees distant. He would look to the viewing aperture when instructed by an auditory cue, but only long enough to register his response to the stimulus. When he had made his response he would turn his gaze back to the peripheral fixation point. The temporal relationships of events in this revised sequence of operation are schematized in Figure 16 (page 128).

Such a change in operating technique would obviously require some reconsideration of the presentation and interval times. It would be necessary to increase the interval time to the next available control setting, setting 3 (2.65 s : Table 5, page 105), in order to accommodate the eye movement. The interval must allow time for the 15 degree return eye movement after one response, a pause for fixation and then, when the auditory cue is sounded, for the fresh refixationary movement of 15 degrees to the viewing aperture in preparation for the appearance of the next broken ring stimulus. A decision was made to increase the presentation time to the next control setting, setting 2 (2.92 s). Thus the maximum time available for a response would remain slightly longer than the interval period, as in the previous work. It was felt reasonable that a little more latitude should be allowed to the subject with regard to the time available

FIGURE 16 : Schema - The temporal relationships of events in the revised sequence of operation associated with the TV system (vide text, pages 127 and 152).

FIG. 16


off
response
on
PRESENTATION
INTERVAL
AUDITORY CUE
(delay)
eye
movement
TIME
zero

for inspection of the stimulus, reaching a decision and making a response subsequent to a potentially visually disruptive eye movement (especially in the proposed context of soft contact lens wear). Also, it is worth emphasizing here that the stated presentation time is by way of an absolute maximum presentation time : in operation the broken ring stimulus should never remain on the TV screen for this length of time. Provided that the subject follows the instructions that he has been given, he will have responded by depressing one of the four push buttons on his hand control box before the stimulus is extinguished, even if the subjective response was felt to be largely a matter of guesswork.

This third and final validation study of the TV system would thus be undertaken to assess the necessity for, and optimum direction of, the 15 degree ocular excursion. In view of the proposed eventual utilization of the TV system in a study of a particular aspect of soft contact lens visual performance, it would be appropriate that this work should be undertaken with the subject wearing a soft contact lens correction. The direction chosen for the specific eye movement would then be the most suitable one for this future work. Finally, the study would provide the investigator with ample experience of operation of the revised procedure, and any alterations found necessary could then be noted for adjustment in future work.

Weighing the time available for the work against the fairly large number of data collection visits anticipated, and in the context of the favourable results arising from the repeatability study (reported in Section 7.2B, pages 175-176), it was decided that a small group of subjects would be satisfactory for this study. All subjects

would be naïve observers, being spectacle wearers who could achieve at least $^{6}/_{4}$ on the Landolt chart with a correction before their dominant eye alone. They should have had no previous experience of contact lens wear of any sort and be chosen with due attention to the cylindrical component of their spectacle prescription, since the level of vision with a prescription soft contact lens fitted to their dominant eye should be such that it equals that level obtainable with spectacles.

Aside from an initial screening visit, and attendances for an optometric examination and for a soft lens fitting, a sequence of twelve data collection visits would be undertaken, each exactly one week apart : Table 7 (page 131) lists these visits.

The first, second and twelfth visits may be regarded as control sessions. At these three visits the usual operating technique would be used, i.e., steady fixation and no eye movements. A direct comparison of subjective responses would then be possible, not only between the two forms of optical correction (spectacles and soft contact lens) but also between the two identical soft contact lens sessions eleven weeks apart. This latter comparison would serve to indicate whether there had been any adaptation to the soft contact lens over the study; it is important that the subject does not adapt to the contact lens, as this could introduce unwanted variation into the results. Aside from the administrative reasons already mentioned in Section 5.2A (pages 120-121) concerning the availability of the subject group (University students), the spacing of the visits at weekly intervals was with the specific intention of minimizing any chance of adaptation. The subject would wear his single lens for barely one hour at each visit, and the lens would remain in the

Table 7: STUDY NO. 3 - The Sequence of Visits

Visit Number	SUBJECT 1	2	3	4	5
1	Spectacles ..... no eye movement				
2	Soft Contact Lens ..... no eye movement				
	Soft Contact Lens ..... eye movement to a specified fixation point[a]				
3	2	3	7	6	4
4	4	5	6	3	2
5	1	8	5	8	1
6	6	7	8	7	6
7	7	4	3	1	5
8	3	1	2	2	8
9	8	2	4	5	3
10	5	6	1	4	7
11	Soft Contact Lens .. four-point eye movement				
12	Soft Contact Lens ..... no eye movement				

a Fixation point (as viewed by the subject): refer to Figure 15 (page 126).

research clinic between visits.

At visits three to ten(inclusive) the modified operating technique would be in operation, the subject looking to and fro from a different fixation point at each weekly visit. The tabulated directions of testing (Table 7, page 131) at these visits were determined via a table of random numbers (Rohlf and Sokal 1969).

At the penultimate visit a multiple eye movement around the four oblique fixation points (commencing at point 8 and proceeding, in a clockwise direction, to points 2, 4 and 6) would be undertaken before the subject viewed the stimulus. On this one occasion the interval period would be extended to the highest level, control setting 6 (4.71 s : Table 5, page 105).

Five repeated monocular runs would be undertaken at each of the twelve visits; informal trials at the revised control settings of presentation and interval times indicated that one run of one hundred stimuli now took around seven or eight minutes to complete. Thus five runs, subsequent to twenty minutes adaptation to the soft contact lens (a suitable time as recommended in the contact lens manufacturer's fitting mannual : Anon 1978b) produced an experimental session of about one hour's duration, a timespan found acceptable in the two previous studies for sustained subjective attention. Again, as in the two previous studies, payments to the subjects should be delayed until the successful completion of data collection at the twelfth visit.

5.3 The Visual Performance of Subjects Adapting to Soft Contact Lens Wear

The TV system which has been described in Section 4.3A (page 81 et seq.) was constructed with the intention of providing a means of investigating a subject's visual performance. The three sequential studies outlined in Sections 5.2A - C (vide supra) were devised to assess the completed system, the objective being to establish a repeatable and informative procedure for routine use in a clinical environment. If a reliable procedure could be evolved, then the TV system could be incorporated into a study designed to investigate a specific aspect of visual performance.

The entire three year project reported herein was supported by a research contract awarded to The University of Aston in Birmingham by Hydron Europe+, an international soft contact lens manufacturer. This company, at the time of commencement of the study (Spring 1978), had recently established a lens production base, with full research and development facilities, in Great Britain. Before any work was undertaken in connection with the project, several exploratory meetings were held to allow discussion between the two parties with regard to the aims and scope of the study.

A concise and self-limiting study area was sought, preferably in a direction which, from a review of the literature, was relatively

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+ Hydron Europe, a Division of National Patent Development Corporation : Head Office - Hydron Eurcpe Ltd., Hawley Lane, Farnborough, Hampshire, GU14 8EQ, Great Britain.

unexplored. In this connection the subject of blinking was touched upon in discussion. A direct investigation of the rate of blinking, of itself, albeit in a soft contact lens environment, had little to commend it. However, a more promising avenue of study would be opened up by laying the emphasis of the investigation upon the rôle of blinking as it relates to the experience of the new soft contact lens wearer : i.e., an investigation of an individual's blink strategy during the period of adaptation to this novel refractive correction. The assessment of the individual's visual performance over this same period would be a logical corollary in such a study.

Consequently, whilst the first stage of the experimental work with the TV system was being undertaken, the decision was made that, provided the results of the assessment work proved satisfactory, the second stage would proceed along the lines outlined above. There would be an investigation of the possibility, and degree, of an inter-relationship between visual performance and blink strategy in the new soft contact lens wearer.

Before the rationale of the design of this major experiment is discussed, it would be appropriate to briefly review the subject of blinking. Duke-Elder (1968) defines a blink as "...the temporary closure of both eyes, involving movements of the upper and lower lids effected by the palpebral portion of the orbicularis oculi muscle". It may be voluntary or involuntary. The physiological basis of blinking has been thoroughly investigated : Duke-Elder (1968) has produced a review of eyelid movements and the published work, including that of Ponder and Kennedy (1927), Hall (1936, 1945), Gordon (1951), Haberich (1967) and most recently Doane (1980), has

provided considerable insight into this action. The normal or spontaneous blink is an active reflex movement, lasting about 0.40 s and is made up of 0.05s of closure, 0.15 s of stasis and 0.20 s of opening. The frequency of blinking varies between individuals, the usual range being between six and thirty blinks per minute, with an average of around twelve per minute.

The effects upon blinking brought about by, specifically, the introduction of a contact lens onto the eye, have also been catalogued. The available evidence seems to indicate that, whilst soft contact lenses may have little effect, hard contact lenses can have a significant effect upon an individual's blink characteristics (especially in the unadapted eye) : this effect is felt to be the result of a foreign body-type reaction in the eye of the wearer (Brown et al 1973). Detailed guides or recommendations have been published to promote the development of 'correct' blinking in contact lens wearers : prominent among these are the papers of Stewart (1968), Korb and Korb (1970) and Mackie (1970), all aimed at improving the comfort and vision of the hard lens wearer. Alexander-Katz (1971) has stressed the importance of full-aperture blinking in soft lens wear, and the soft contact lens manufactuers' fitting manuals make similar recommendations for implementation from the adaptational period onwards.

The various techniques for monitoring and recording eyelid activity have been reviewed by York (1969). For the purposes of the proposed work, a non-contact, readily mountable and adjustable means of monitoring would be required, ideally with a continuous read-out of data. It would also be preferable that the subject should be unaware that his blink activity was being monitored. A photoelectric technique,

similar to that first described by Franks and Withers (1955), would seem to be the ideal option. It should be possible to mount a photocell, on an adjustable clip, upon either side arm of the trial frame worn by the subject. The photocell would then register changes in reflected light due to lid movement. Its output could be amplified and then used to drive a recording device, thereby producing a continuous record of the subject's blink activity during the course of a run with the TV system. No physical connections between subject and apparatus would be necessary and alignment, both between different subjects and between the two eyes of an individual subject, could be accomplished fairly rapidly; these are both significant considerations where appointment schedules are concerned. A further bonus which such a system would provide is the facility for continuous data recording with instantaneous read-out. This is a feature denied by, for example, photographic monitoring techniques, and of course is much more accurate (and practicable) than mere direct observation of the subject's eyelid movements by the person in control of the experimental session.

A slight problem associated with the use of a photocell might arise in connection with variations in ambient light conditions. The subject's head is not restrained in any way during the course of experimental runs with the TV system. Thus the casting of shadows or indeed any vibrations arising from changes in head and body posture must not interfere with the accuracy of the photocell activity. To this end, it may prove necessary to fix a small local light source at the side of the photocell, on the same clip mounting. This would provide a discrete, dim but homogeneous, area of illumination on the temporal conjunctiva of the eye under investigation;

the reflection from this spot of light would then be disturbed when the subject blinked and thence trigger the photocell, the latter working upon the principle that the intensity of incident illumination governs the current that it passes. Trials would have to be undertaken to establish the necessity for this refinement, under the usual conditions of operation in the test room.

Blink activity can be described under three headings: firstly, straight-forward blink rate; secondly, blink duration or the length of time it takes for the open eye to close and re-open; and thirdly, blink amplitude or the distance between the upper and lower lids of the open eye. A further somewhat arbitrary distinction is also sometimes made as to whether the lid closure is full or partial. However, bearing in mind that the study would involve, in all probability, a fairly large number of subjects, each undertaking repeated runs with the TV system over several visits, and with each of their two eyes being investigated separately, an early decision was made to record blink activity on a time-base only, i.e., blink rate. The refinements to the monitoring and recording equipment which would be occasioned by the registering of the other aspects of a blink, coupled with the work which would then be necessitated in connection with the calibration and measurement from the numerous recording traces, really could not be justified in terms of the further expense and time which would be required. Further justification for this decision arose in connection with the apparently minimal effects of soft contact lenses upon an individual's blink characteristics (i.e., blink rate, duration and amplitude) as demonstrated by, for example, the work of Brown et al (1973) referred to earlier. Finally, as outlined near the beginning of this Section (vide supra,

page 134), it was the temporal relationships of blink activity in conjunction with response latency and the undertaking of the visual task which were to be of primary interest in the proposed study.

Turning now to specific aspects of experimental design, it was decided that, in the absence of reports of any comparable experimental work, the responses of a large number of eyes should be assessed in order to increase the accuracy of the data generated by the study. Where possible, the two eyes of an individual subject would be used; this would conveniently raise the volume of data generated, yet help alleviate congestion in the rather restricted clinical space available for the work. All subjects would be naïve observers, being spectacle wearers who have had no previous experience of contact lens wear of any sort nor previous contact with the TV system. They should be chosen with due attention to the magnitude of the cylindrical component of their spectacle prescription. The pool of suitable subjects could be divided into groups, based upon their availability and, provided that a rigid experimental procedure was adopted, the groups could have staggered starts thereby making the maximum use of the time available.

Aside from an initial screening visit, the selected subjects would attend for a full optometric examination and also for a soft contact lens fitting (lathe cut, standard thickness, daily wear variety). When their lenses arrived from the manufacturer and had been checked, each subject would attend for an appointment to enable an assessment to be made of the lens fit and the vision; in addition, this visit would provide an opportunity for the subject to practise lens insertion and removal, and also general care and handling. When all

preparations were complete, each subject would then agree upon a fixed sequence of seven data collection visits. At the first of these visits (the control session) the subject would wear his best spectacle correction, made up in trial lens form, in the usual spectacle plane. The second visit would be one week later, on the first day of regular soft contact lens wear and approximately one hour after lens insertion. Three data collection visits would fall in the first week of lens wear, on days number 1, 3 and 5. The remaining three visits would then follow at weekly intervals, on days number 10, 17 and 24 : these last three visits (only) would have a tolerance of plus/minus one day, partly to facilitate time-tabling of the staggered groupings and party to convenience the subjects where necessary. However, for each subject the appointment time should be the same for all his visits, to ensure that on each occasion he had been wearing his lenses for a similar length of time. (The pending results of the second validation study on repeatability, outlined in Section 5.2B (pages 121-123), would be of significance when finally establishing the details of this fourth study). At each visit, where both eyes of a subject are to be used, runs should always be undertaken in the first instance upon the right eye, followed by a brief rest before the left eye is assessed.

The time scale of one month for the soft contact lens section of the study was decided upon after much discussion. The primary consideration was to avoid complications arising as a consequence of the visual and mechanical results of the build-up of deposits upon the surface of the soft lens : this problem has previously been discussed in Section 1.3Div (pages 20-21). The literature is inconclusive as regards the usual time of onset of problems associated with surface

deposition. Certainly, there is considerable variation amongst individuals, but the earliest manifestations of such problems (frequently, for example, poor or unstable vision, often associated with decreased comfort) are usually of the order of months after the commencement of regular lens wear. Larke (1979 : personal communication) has stated that such complications are not usually evident in the first two months of wear, at least. Probably of equal importance, however, from the point of view of running such a study, is the consideration of subject numbers and attendances. Potential volunteer subjects would not be attracted by the prospect of a protracted sequence of visits; the drop-out rate could be high and ensuring regular attendance could be a problem, i.e., there could be poor control over the study, resulting in an unacceptably high number of missed data collection points. Consequently, from a consideration of all these points, it was decided that the first four weeks of regular daily soft contact lens wear would provide a suitably concise investigative time span for the study.

Following the pattern of previous work with the TV system, at each session the subject would undertake several repeated runs at fixed control settings under monocular conditions : an indication of the optimum number of repeated runs (each run comprising, as usual, one hundred stimuli) will be obtained from the results of the second validation study prior to commencement of this work. As has been described in Section 5.2C (pages 125-127), in an attempt to more accurately simulate normal viewing conditions, a 15 degree ocular excursion was incorporated into the operating procedure. Pending analysis of the results of this study to indicate a possible optimum direction for this eye movement, it was decided to retain this

feature in the present work. Consequently, the control settings of the TV system and auxiliary equipment would also be as described in Section 5.2C (pages 127,129). Additional equipment would be required for this study, to provide a continuous record (on, for example, paper or magentic tape) of the subject's blink activity and, concurrently, his response latency with regard to each presented stimulus over individual runs with the TV system. The practicalities of this procedure will be addressed more fully in Chapter 8. Taped instructions would be delivered, and ample trial runs and rest periods would be permitted.

At each of the six contact lens visits the subject would be required to assess subjectively three aspects of soft contact lens wear, based upon his experience to date : the stability and quality of vision, and also lens comfort. Each eye should be considered independently, and the subject's responses should be limited to marking a tick against one of five statements under each of the three headings, with the provision of further space at the foot of the single sheet questionnaire for any additional comments. Again, as in the previous work, the duration of each experimental session should be ideally in the region of one hour.

In contrast to the practice employed in all three of the studies which comprised the validation work, no financial reward would be paid to subjects in this major study. Instead, the attraction publicised to encourage potential subjects to volunteer their services would be the provision of a pair of daily wear soft contact lenses for a fee substantially below that charged in private optometric practice. As a further incentive to ensure attendance at all six of the required

data collection visits (since, in effect, the subjects would be wearing what were technically their own contact lenses from day number 1 of the study) it would be made clear to the subjects accepted for the work that a fifty per cent refund of their fee would be made on satisfactory completion of the seventh and final data collection visit, i.e., at the end of the first month of regular daily lens wear. It was hoped that this would prove a sufficiently attractive proposition to motivate a suitable number of persons to volunteer for participation in the study.

CHAPTER 6

THE ASSESSMENT OF THE TV SYSTEM'S CAPABILITY AS A RESEARCH TOOL FOR THE INVESTIGATION OF VISUAL PERFORMANCE

CHAPTER 6

THE ASSESSMENT OF THE TV SYSTEM'S CAPABILITY AS A RESEARCH TOOL FOR THE INVESTIGATION OF VISUAL PERFORMANCE

6.1 STUDY No. 1 : To Establish the Optimum Level and Direction of Contrast with regard to the Televised Stimuli

(Refer to Section 5.2A, commencing page 117)

6.1A Introduction and Details of Subject Group

A pool of potentially suitable subjects was formed as a result of persons responding to advertisements calling for volunteers : an example illustrating the general form of such advertisements is provided in Appendix X (Figure 31, page 470). It was the intention to use different groups of subjects for the different phases of the work. In the initial absence of any accurately-determined data from the TV system, this admittedly uneconomic approach (in terms of the number of potential subjects required and the time spent screening the same) was felt to be an advisable precaution. The incentive offered to attract potential subjects in this first series of studies was the provision of a modest cash payment on successful completion of all the relevant experimental visits.

For the first study, twenty-one persons (12 males, mean age 22.92 $\pm$ 2.98 years; 9 females, mean age 22.04 $\pm$ 2.26 years : group, mean age 22.54 $\pm$ 2.67 years) were selected from the pool of subjects on the basis of an acceptance profile (Appendix XIIA, page 494). The pertinent details of this group are summarised in Table 8 (page 145). The group was subdivided on the basis of their best subjective binocular

Table 8: STUDY NO. 1 - Details of the subject group

SUBJECT No.	Sex	Age (Years)	R / L - Spectacle Rx	Binocular Landolt Visual Acuity
1	F	23.75	-0.50, -0.25 X 10 -0.50, -0.50 X 175	6/3
2	M	26.84	-1.75, -1.50 X 150 -0.75, -0.25 X 180	4+
3	F	22.84	-2.50, -1.25 X 90 -3.00, -1.75 X 70	4+
4	M	24.67	-0.75, -0.75 X 90 -3.00, -1.00 X 30	4.5
5	F	19.42	-4.00, -0.25 X 180 -3.25, -0.50 X 180	4.5
6	M	22.42	-0.50 -0.75	5
7	F	25.08	-2.25, -0.75 X 140 -0.25, -0.75 X 180	5
8	F	23.33	-4.00, -0.25 X 180 -1.00, -1.00 X 10	5
9	M	21.42	-6.50 -8.00	6
10	M	26.92	-3.50 -4.25, -0.25 X 90	6
11	M	18.92	-6.25 -6.75	7.5
12	M	22.08	-5.25 -5.75	4
13	M	19.17	-5.00 -5.25	4
14	F	19.17	-0.75 -0.25	4
15	M	19.33	-1.50 -1.50	4
16	M	26.67	-4.00, -0.75 X 90 -3.25, -1.25 X 172½	4
17	F	20.17	-2.00, -1.75 X 5 -0.25, -1.50 X 160	4
18	F	24.25	-6.00 -6.25, -0.50 X 90	4
19	M	22.08	-5.50, -0.25 X 90 -5.00	4
20	F	20.33	-1.50 -1.50	4
21	M	24.50	-2.75, -0.75 X 110 -2.00, -1.25 X 45	4

visual acuity : the entire group covered the range $^{6}/_{3}$ to $^{6}/_{7.5}$ inclusive, and included ten persons (6 males, mean age 22.31 ± 2.92 years; 4 females, mean age 20.98 ± 2.24 years : group, mean age 21.78 ± 2.62 years) who recorded best subjective binocular visual acuity of $^{6}/_{4}$. In all cases the best subjective binocular visual acuity was determined at 6m on the internally illuminated Landolt ring test chart (conforming to B.S. 4274 : 1968) when the subject was wearing his or her best spectacle correction in the form of accurately centred full aperture trial case lenses (conforming to B.S. 3162 : 1959b). It should be noted here that in this and in all other studies where the spectacle correction was made up from trial case lenses, for reasons of approximate equality of light transmittance there were always two, and only two, lenses in the cells of the trial frame before the appropriate eye. Usually these lenses corresponded to the spherical and (negative) cylindrical components of the prescription; in other cases, the spherical prescription less -0.50D was mounted in the rear cell (nearest to the eye), and the remaining -0.50D sphere was mounted in the revolving front cell in the location usually occupied by the cylindrical element.

6.1B Description of Experimental Method

Aside from the initial screening visit and an appointment for an optometric examination, all twenty-one subjects made two data collection visits exactly one week apart; each of these two visits was at the same time at each attendance, and the duration of each visit was approximately one hour. At each visit the full accurately centred spectacle correction was placed in situ and visual acuities were checked subjectively on the Landolt chart in the test room.

When the subject arrived for his appointment the TV system was switched on so that, while the various preliminary checks were being made, it would have time to attain its optimum operating level (i.e., the operating temperature of certain of the electronic components). When all was ready, the various control settings were checked as per the list given in Appendix XIIIA (page 501). Then, at both visits, the pre-recorded operating instructions were delivered (Appendix XIVA, pages 506-507) and several trial runs at the highest contrast level, setting 1 (55.02% : Table 4, page 99) were undertaken to provide the subject with confidence and experience of operation.

When both the subject and the investigator felt that data collection could commence, the sequence of twelve runs at various selected combinations of level and direction of contrast described in Section 5.2A (vide Table 6, page 120) were undertaken. As per the procedure outlined in Section 4.3Biii (page 110 .) the subject lightly rested the back of his head against the vertical head restraint attached to the hydraulic chair and steadily fixated the viewing aperture on the mirror 2.5m in front of him whilst each run of one hundred stimulus presentations and responses was undertaken. The subjective responses were monitored and assessed for correctness by the investigator during the course of each data-generating run, and the results were recorded manually on charts especially designed for this purpose (Appendix V: Figure 27, page 427). Requests for rests between runs were permitted, the subject being encouraged in this event to change his position slightly in the chair and to allow his gaze to wander around the test room in this short period of relaxation.

On completion of each session of twelve runs the TV system was

switched off. Then, as he had been advised at the commencement of the session, the subject was asked to register whether he had any preference for responding to dark stimuli on a lighter background or the reverse situation, irrespective of the contrast level. Finally, the trial frame was removed and his own spectacles were returned.

6.2 STUDY No. 2 : To Investigate the Degree of Repeatability of the Data Generated by Subjects Using the TV System

(Refer to Section 5.2B, commencing page 121)

6.2A Introduction and Details of Subject Group

Five persons (all males, mean age 21.12 $\pm$ 1.49 years) were selected from the pool of subjects for participation in this study on the basis of an acceptance profile (Appendix XIIB, page 495). Their relevant details are summarized in Table 9 (page 149). All the subjects were naïve observers and had previously undergone an optometric examination. They all recorded a monocular acuity of at least $^{6}/_{4}$ with their dominant eye when wearing their best spectacle correction in the form of trial case lenses in the usual spectacle plane and viewing the internally illuminated Landolt ring chart at 6m in the test room.

6.2B Description of Experimental Method

The five subjects each made two data collection visits, both visits being on the same day. The first visit was at 9.00 a.m., and the second at 4.00 p.m. Each of the five subjects was assigned, on an entirely random basis, to a particular day (Monday to Friday) in the week

Table 9: STUDY NO. 2 - Details of the Subject Group.

SUBJECT No.	Sex	Age (Years)	R^a Spectacle R_x	Monoc Landolt VA
1	M	19.84	- 5.00	6/4
2	M	20.08	- 1.50	4
3	M	20.17	- 4.00, - 0.25 x 180	4
4	M	22.75	- 5.50, - 0.25 x 90	4
5	M	22.75	- 5.25	4

a All subjects revealed to be consistently right (R) eye dominant, using several sighting tests (Borish 1970).

allotted for the undertaking of this study. The duration of each visit was in the region of fifty minutes.

At the commencement of both visits the monocular visual acuity was checked, the subject wearing the best spectacle correction before the dominant eye, the other eye being occluded. Before data collection commenced, the various control settings were checked (Appendix XIIIB, page 502), the pre-recorded operating instructions were delivered (Appendix XIVB, page 508) and several trial runs at the chosen contrast level and direction+, setting 3/BLACK (-35.62% : Table 4, page 99) were undertaken.

When both parties agreed that sufficient experience of operation had been gained, the sequence of ten repeated runs at the fixed contrast level, setting 3 (35.62%) and all at negative contrast (i.e., dark stimuli on a lighter background) were undertaken. As in the previous work, the subject could request short rest periods between the individual runs of one hundred stimuli.

+ The results of the experimental studies are described later (Chapter 7). Suffice it to say here that an analysis of data generated by Study No. 1 indicated that contrast setting 3 (35.62%), under conditions of negative contrast, would be the most suitable single operating level for this and subsequent work.

6.3 STUDY No. 3 : To Investigate the Effect of the Incorporation of a Specific Ocular Excursion into the Operating Procedure

(Refer to Section 5.2C, commencing page 123)

6.3A Introduction and Details of Subject Group

As had been discussed in Section 5.2C (page 123 et seq.), it was felt that an ocular excursion should be incorporated into the TV system's operating procedure, in an attempt to more nearly simulate normal viewing conditions. An amplitude of 15 degrees (a linear displacement of 0.67m : Figure 15) was chosen for the eye movement. Since the optimum direction of this movement was to be investigated, it was decided that eight possible directions of gaze in the horizontal, vertical and oblique meridians around the visual task should be investigated.

The locations of eight peripheral fixation points were established on the uniform neutral grey general surround at the visual task (Figure 15, page 126). Eight small pieces of rubberized magnetic strip were located behind the grey cardboard surround in these positions and glued in place. Another piece of rubberized magnetic strip, of opposite polarity, was stuck to the reverse of an 0.8cm diameter red label : i.e.,  (actual size). The fixation spot thus produced could conveniently be moved between any one of the eight positions without leaving a mark. It was easily visible, both by virtue of the fact that 0.8cm at 2.50m corresponded to a solid angular subtense of eleven minutes, and also as a consequence of its fluorescent ('day-glo') colour. Thus the subject's attention

could be directed precisely to any one of eight possible positions.

It was decided that an auditory signal would be the most suitable means of indicating to the subject when to shift his direction of gaze. In order that the subject should undertake his 15 degree ocular excursion at the same point in time prior to each stimulus presentation, zero time was defined as that point when the previous stimulus disappeared from the TV screen (i.e., when the subject had made his previous response). A specific time delay would operate each time. Thus the interval time was divided into two periods : after a response had been made, a fixed time (corresponding to the selected auditory cue delay time) was available for the eye movement back to the peripheral fixation spot and, after the cue sounded, a fixed time for the ocular excursion to the viewing aperture again. The temporal relationships of events in this revised sequence of operation associated with the TV system have been schematically represented in Figure 16 (page 128).

At this stage it was considered important that the position and alignment of the TV apparatus on the bench in the test room should not be disturbed; also any interference with the TV system's electronic control circuitry was to be avoided. Thus is was decided that the miniature indicator bulb which glowed red when the stimulus was being presented on the TV screen should be used to trigger the auditory cue. A miniature photocell was mounted near the end of a rubber sleeve (to shield the former from all ambient light); this sleeve was then clipped over the protruding glass envelope of the miniature bulb, where the latter stood proud of the flat aluminium face of the control panel. Thus, when the broken ring stimulus was presented on the TV screen,

the indicator bulb glowed and activated the photocell. A small current then flowed around a control circuit, triggered a relay switch and thereby isolated the cue device. When the stimulus disappeared from the screen (i.e., when the subject responded to the stimulus by depressing one of the four buttons on his hand control box) the TV system's indicator lamp ceased to glow, the photocell was not activated, the control circuit was broken and the relay switched the cue device into circuit again. The auditory cue device incorporated a selection of delay times; previous informal trials had indicated that, for an interval time of 2.65s (setting 3) a suitable delay was 1.50s.

Thus, in the revised operating technique, the subject fixated the peripheral red spot placed in one of eight alternative positions and, when the cue sounded, moved his gaze (i.e., an eye rather than a head movement) directly to the viewing aperture. The timing was such that he had ample time to undertake this ocular excursion and make ready for the onset of the stimulus. A broken ring would then appear and he would respond promptly and as accurately as possible to it, and then immediately avert his gaze back to the specified peripheral spot, which he would steadily fixate until the cue sounded again.

This third study was conducted to determine the optimum direction of the ocular excursion. Five persons (all males, mean age 24.24 $\pm$ 2.53 years) were selected from the pool of subjects for participation in this study on the basis of an acceptance profile (Appendix XIIC, pages 496-497). All the subjects had previously undergone an optometric examination and had subsequently attended for a contact lens fitting, where they had each been prescribed a standard thickness

Table 10 : STUDY NO. 3 - Details of the Subject Group

SUBJECT No.	Sex	Age (Years)	KERATOMETRY K_H : K_V	REFRACTION R[a]- Spectacle Rx	REFRACTION Ocular[b]	SOFT LENS[c] BCOR : Ø : D	Monoc Landolt VA[d]
1	M	20.84	8.025 X 20 : 7.800 X 110	-3.25,-0.50 X 175	-3.13,-0.46 X 175	9.30 : 14.5 -2.75	6/4
2	M	25.92	8.250 X 40 : 8.350 X 130	-3.00,-0.50 X 120	-2.90,-0.46 X 120	9.30 : 14.5 -3.25	4
3	M	23.50	7.325 X 5 : 7.362 X 95	-5.25, -0.75 X 95	-4.94,-0.66 X 95	8.40 : 14.0 -5.00	4
4	M	23.50	8.025 x 5 : 7.887 X 95	-5.25, -0.50 X 150	-4.94, -0.44 X 150	9.00 : 14.5 -4.75	4
5	M	27.42	7.937 X 45 : 7.875 X 135	-4.00	-3.82	8.70 : 14.5 -3.75	4

a All subjects revealed to be consistently right (R) eye dominant, using several sighting tests (Borish 1970).

b Calculated assuming a Back Vertex Distance = 12 mm.

c Standard thickness daily wear soft hydrophilic (hydrogel: pHEMA) contact lens manufactured by Hydron Europe Ltd.

d Level attainable with spectacle lens or soft contact lens refractive correction.

daily wear soft contact lens (Hydron Europe) for their dominant eye alone. The lenses were fitted by a regular, established routine and with certain constraints governing the choice of lens parameters, as outlined in Appendix XI (Figure 46, pages 490-492) :this was in an attempt to minimize any visually-disruptive effects resulting from an embarrassment to normal corneal metabolism, as discussed in Sections 1.3Diii and 1.3Dv (pages 19 and 22-23, respectively). The subjects all recorded a monocular acuity of at least $^{6}/_{4}$ on the Landolt chart with their dominant eye when wearing their best spectacle correction and, after a period of twenty minutes adaptation, when wearing their soft contact lens. All relevant details are summarized in Table 10 (page 154).

6.3B Description of Experimental Method

Each of the five subjects made twelve weekly data collection visits, each attendance being of approximately one hour's duration and commencing at the same time on every occasion.

The visits followed the sequence as outlined previously in Table 7 (page 131). The first, second and last visits did not involve any eye movement, i.e., the operating procedure was as in the first two studies : these visits were intended to be control visits. For the first visit the subject wore his best spectacle correction in the trial frame in the usual manner, and for sessions two and twelve the soft contact lens was worn. Visits three to ten worked through the eight directions of eye movement in a random manner, the revised operating procedure as described in Section 6.3A (page 153) being used. As described in Section 5.2C (page 127), for this study

the interval period was increased to control setting 3 (2.65s : Table 5, page 105) to accommodate the eye movements, and the stimulus presentation time was correspondingly revised to control setting 2 (2.92s). Visit eleven was a special visit; a four-point eye movement was undertaken. When the subject had responded to a stimulus, instead of looking directly back to a single peripheral fixation spot, he was instructed to look purposefully from one to the next of the four oblique fixation spots; thus, he would look up to point 8 and then, in a clockwise fashion, to points 2, 4 and 6 (Figure 15, page 126). With a little practice it became possible to accomplish this four-point movement just before the cue sounded. When the latter did sound, the subject looked from fixation point 6 back to the viewing aperture. The interval time was extended necessarily to the maximum level, setting 6 (4.71s), specifically for this one session, and the cue delay was correspondingly altered from 1.50s to 3.30s to allow time for the undertaking of the multiple eye movement.

The procedure at the first (spectacle lens) visit was as in Study No. 2. The best spectacle prescription was centred before the dominant eye, the other eye being occluded. The TV system was switched on, the control settings were checked (Appendix XIIIC, page 503), and the pre-recorded instructions were delivered (Appendix XIVB, page 508). Then several trial runs were undertaken at contrast setting 3/BLACK. When both parties agreed that sufficient experience of operation had been gained, the sequence of five monocular runs were undertaken, all being at negative contrast and at contrast setting 3 (-35.62%). Rest periods were permitted between the individual runs of one hundred presentations. This first visit was of approximately forty-five minutes duration in all cases.

A similar procedure was followed at visits two and twelve, except that the subject wore his soft contact lens. When the subject attended, his sterile prescription soft lens was taken from its glass storage vial, rinsed with normal saline and them put on the appropriate eye and allowed to settle for twenty minutes. During this time the subjects, without exception (because of the dual elements of novelty and slight dis-orientation associated with the wearing of a single prescription contact lens), elected to remain in the waiting area attached to the research clinic and engage alternately in conversation and the reading of the magazines provided. When the period of adaptation had elapsed, the fit of the lens was quickly checked, the non-dominant eye was occluded and the visual acuity level assessed on the Landolt chart. The TV system had been switched on previously and now the pre-recorded instructions (as at the first session : Appendix XIVB, page 508) were delivered. The five monocular runs, with rests, were then undertaken under similar conditions to the first visit. On completion, the visual acuity and lens fit were reassessed before the lens was removed. The cornea of the subject was checked following the instillation of vital stains (one drop 2.0% W/V Fluorescein Sodium B.P. and one drop 1.0% W/V Rose Bengal)‡ on the slit lamp biomicroscope, under both white and ultra-violet light, and finally his own spectacles were returned to him.

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‡ Vital stains in the form of Minims^{R} : 0.5 ml units of sterile single-dose disposable eyedrops, containing no chemical preservative. Manufactured by Smith and Nephew Pharmaceuticals Ltd., formerly of Welwyn Garden City, Herts., but since October 1981 at Bampton Road, Harold Hill, Romford, Essex, Great Britain.

At visits three to ten the operating procedure described in Section 6.3A (page 153) was followed. The subject attended, and adapted to his soft contact lens for twenty minutes before the fit and visual acuity was checked. When all was ready, the revised operating instructions were given (Appendix XIVC, pages 509-510). Several trial runs were permitted to ensure a thorough grasp of the modified technique; this was important, in order to avoid any possibility of confusion arising with regard to the procedure at the two previous visits, where the subject was required merely to steadily fixate the viewing aperture. Then, when the subject and investigator were agreed that the revised operating technique had been mastered, the sequence of five monocular runs were undertaken; rests were permitted, as usual. On completion of the five runs, visual acuity and contact lens fit were reassessed, the lens was removed and the subject's cornea was examined with vital stains on the slit lamp; the subject was then discharged until the following week.

The penultimate session followed an identical pattern to visits three to ten, but with the revised pre-recorded instructions (Appendix XIVD, pages 511-513) advising the subject to undertake the multiple (four point) eye movement before each stimulus presentation. Because the interval had been lengthened, the undertaking of several trial runs and then the five data collection runs produced a protracted session; this particular visit was, in all five instances, in the region of ninety minutes duration.

Two further points of general experimental procedure should be noted here in connection with this third study. Firstly, it should be stated that no proprietary contact lens solutions were used in this

work. To prevent the occurrence of any problems associated with subjective sensitization to the preservative in these solutions, and also to ensure sterility, individual guaranteed-sterile-until-opened dispenser packs of normal saline* were used to rinse the lenses. The investigator was the only person to handle the lenses; the hands were always washed and shaken (not towel-dried) before this was done. When the lens was removed from the subject's eye, it was inverted in a pool of normal saline in the palm of the left hand and rubbed smoothly for a few moments with the right forefinger, with the intention of mechanically lifting off any tear debris adhering to the lens. The soft lens was then rinsed with more normal saline and returned to its labelled glass storage vial, the latter being two-thirds full of the same. The vial was capped and crimp-sealed with an aluminium lid, and then heat sterilized by partial immersion in a water bath for thirty minutes at a temperature in the region of 90°C. The vial was then put in a wire rack to cool and await the next data collection visit.

The second point to be noted is that, after the first two visits incorporating the revised operating technique (i.e., sessions three

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* Normal saline in the form of Salettes^{R} : 10 ml units of sterile saline, containing 0.9% Sodium Chloride B.P. buffered with Sodium Phosphate B.P. and Sodium Dihydrogen orthophosphate analar to give pH 6.8-7.2, containing no preservative. Manufactured by Sauflon Pharmaceuticals, 14-16 Childs Place, Earls Court, London, Great Britain.

and four) the pre-recorded tape was not played to the subject unless he requested to hear it. However, trial runs were always undertaken to ensure that the subject was entirely familiar with the operating technique.

CHAPTER 7

EXPERIMENTAL DATA (I): THE THREE VALIDATION STUDIES

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EXPERIMENTAL DATA (I):
THE THREE VALIDATION STUDIES

7.1 STUDY No. 1 : To Establish the Optimum Level and Direction of Contrast with regard to the Televised Stimuli

(Refer also to Sections 5.2A and 6.1, commencing pages 117 and 144 , respectively)

7.1A The Experimental Data and Statistical Analyses

The objective of the three sequential studies comprising the first stage of the formal experimental work was to establish a reliable, repeatable and informative procedure to facilitate the routine clinical use of the TV system in the investigation of a subject's visual performance with a refractive aid.

As described in Section 4.3C (pages 113-114), subjective responses (other than over trial runs) were recorded manually on special charts (Appendix V : Figure 27, page 427). Subsequently, for each completed run, the investigator could total the number of correct responses for each of the ten stimuli, and then each column of raw-score totals could be transformed mathematically by the application of the correction for guessing factor (Appendix V, pages 426-430).

The first study generated a large file of subjective response data over twelve experimental treatment levels (with a single replication

at each level). This data, as prepared for analysis, is listed in Appendix I : Table 19, pages 256-263. For handling in the statistical procedure, the transformed data was summed over the duplicate runs undertaken at each of the twelve experimental treatment levels : the resulting lists of figures were then punched onto cards in preparation for submission to The University of Aston in Birmingham's main computer (International Computers Limited, ICL 1900 System). An application program (University of Aston/Applied Psychology, Ref: UA31; language ALGOL : vide Appendix VIA, pages 432-434) was used to undertake a three-way analysis of variance (Appendix VIIA, pages 453-454) with repeated measures (3) (completely crossed design) upon the data.

Two data sets could be identified. The one comprised the data generated by the main group (N=21) of subjects, these persons exhibiting a range of binocular Landolt visual acuity values between $^{6}/_{3}$ and $^{6}/_{7.5}$; the second set corresponded to the sub-group (N=10) of subjects with a uniform Landolt visual acuity level of $^{6}/_{4}$.

The results of the statistical analyses of the data sets are summarized in Table 11 (page 164) : full sets of results are provided in Appendix I : Table 20, pages 264-266. The trends demonstrated here may be seen to be identical for both groups of subjects, i.e., whether group visual acuity levels were uniform or disparate. The first variable, the direction of contrast (i.e., whether the TV stimulus was presented as a dark figure on a lighter background, or vice versa) was revealed as a non statistically significant factor in the generation of a subject's scores with the existing system. This result should be compared with the subjective preferences canvassed from the main group on completion of their experimental visits. Whilst ten

Table 11 : STUDY NO. 1 - The F-ratios obtained for the three main effect variables, and their interactions, when analysis of variance was undertaken on data corrected for guessing.

	Group N = 21 : Various Acuities			Group N = 10 : Uniform Acuity		
FACTOR						
A: DIRECTION OF CONTRAST	$F_{1,20}$ =	0.0414	$p>0.1$	$F_{1,9}$ =	1.9676	$p>0.1$
B: LEVEL OF CONTRAST - %	$F_{5,100}$ =	387.1964	$p<0.001$	$F_{5,45}$ =	315.8112	$P<0.001$
C: LEVEL OF STIMULUS ANGULAR SUBTENSE	$F_{9,180}$ =	515.8566	$p<0.001$	$F_{9,81}$ =	782.2865	$p<0.001$
INTERACTION						
A X B	$F_{5,100}$ =	1.3062	$p>0.1$	$F_{5,45}$ =	1.8831	$p>0.1$
A X C	$F_{9,180}$ =	2.7172	$p<0.01$	$F_{9,81}$ =	2.8647	$p<0.01$
B X C	$F_{45,900}$ =	27.8437	$p<0.001$	$F_{45,405}$ =	28.7861	$p<0.001$
A X B X C	$F_{45,900}$ =	2.0907	$P<0.001$	$F_{45,405}$ =	1.7563	$p<0.01$

of twenty-one subjects indicated that they had no preference, a similar number (ten subjects) indicated that they felt more confident responding to stimuli at negative contrast (irrespective of level of contrast-per cent); only one of twenty-one subjects indicated the reverse. Similar findings were obtained with the sub-group : five of ten subjects indicated that they had no preference, and the remaining five subjects expressed a preference for responding in the negative contrast situation.

The two other experimental variables, viz, the level of contrast-per cent (i.e., between stimulus and background) and the level of stimulus angular subtense (i.e., the critical detail) were both revealed as highly statistically significant factors. This significance was carried through to the quantification of the interaction effects also, where level of stimulus angular subtense was seen to assert itself as a dominant factor : there was shown to be a consistently statistically significant interaction between this factor and the direction of contrast, whereas no statistically significant interaction could be demonstrated, for either subject group, between direction of contrast and contrast-per cent level.

To carry the analysis further, an a posteriori multiple comparison of means for the two statistically significant factors was undertaken : the procedure used was that developed by Tukey (1953 : Appendix VIIB, pages 455-456), being readily performed with the aid of a desk top calculator. Contrast level was the first experimental variable to be investigated : full results of this analysis are provided in Appendix I : Tables 21A, 21B, pages 268-271. Briefly, for the main group (N=21) of subjects (Table 21A) all comparisons of means were

statistically significant at the 1% level, with the single exception of the comparison between the results obtained at the two highest contrast-per cent levels (control settings 1 and 2, 55.02% and 42.81% respectively) which was not statistically significant ($p > 0.05$). Similarly significant results were obtained at the 1% level when attention was directed to the sub-group (N=10) of subjects (Table 21B), with the exception of the comparison between the results obtained at control settings 2 and 3 (42.81% and 35.62% respectively) which was not statistically significant ($p > 0.01$). It may be conjectured that this finding was a consequence of the overall higher uniform Landolt visual acuity level of the sub-group as compared to the main group.

The second significant experimental variable, level of stimulus angular subtense, was then assessed using Tukey's comparative test : again full results are presented in Appendix I : Tables 21C, 21D, pages 272-273. To summarize, however, similar results were obtained for both subject groups. All comparisons of means were statistically significant at the 1% level, other than stimulus comparisons at the two extremes of level of angular subtense. More specifically, comparisons between, on the one hand, the two largest stimuli (numbers 6 and 7 in the repeating cycle of ten), and then conversely, between the two pairs of smallest stimuli (numbers 0 and 8, and 1 and 9) were consistently not statistically significant ($p > 0.05$).+

+ With the exception of comparisons between stimuli number 1 and 8, and 1 and 0, in the main group, which were statistically significant at $p < 0.05$.

7.1B A Preliminary Discussion of Results

The statistical analyses have established the points of significance in the mass of data generated by this first study with the TV system. To aid future experimental design, the implications of the interaction of these factors must also be considered. Graphical means were used to help clarify this point. For each of the six levels of contrast-per cent, the groups' mean scores (as calculated in connection with the analysis of variance procedure) were plotted against the level of stimulus angular subtense. A series of sigmoid curves, typical of a psychophysical testing approach, were generated : these are reproduced in Figures 17A, 17B (pages 168A,B).

The Tukey analyses (Appendix I : Table 21, pages 267-273) would seem to indicate that, of the eight specific levels of stimulus angular subtense available, six or possibly seven (if subjective responses to the two pairs of smallest stimuli could be differentiated) regions of discrete and mutually-exclusive points of data collection could potentially be identified. These levels of subjective response corresponded to stimuli number 0/8, 1/9, 4, 5, 2, 3, 6/7 in ascending magnitude of angular subtense in the repeating presentation cycle.

It was of importance to establish a stimulus and response relationship in order to be able to quantify an individual's visual performance on the basis of his experimental results. The present analyses suggest that the key to the establishment of such a relationship would appear to lie in the choice of a suitably discriminating level of stimulus contrast-per cent. The broad similarity of trends in the graphically represented results of the two subject groups (Figures 17A, 17B, page

FIGURE 17: STUDY No. 1 - The averaged subjective response curves, for the ten levels of stimulus angular subtense, presented at the six levels of contrast-per cent (all data corrected for guessing)

FIGURE 17A: Data for the main group of subjects (N = 21) - various acuity levels

FIGURE 17B: Data for the sub-group of subjects (N = 10) - uniform acuity level

FIG. 17A- N = 21

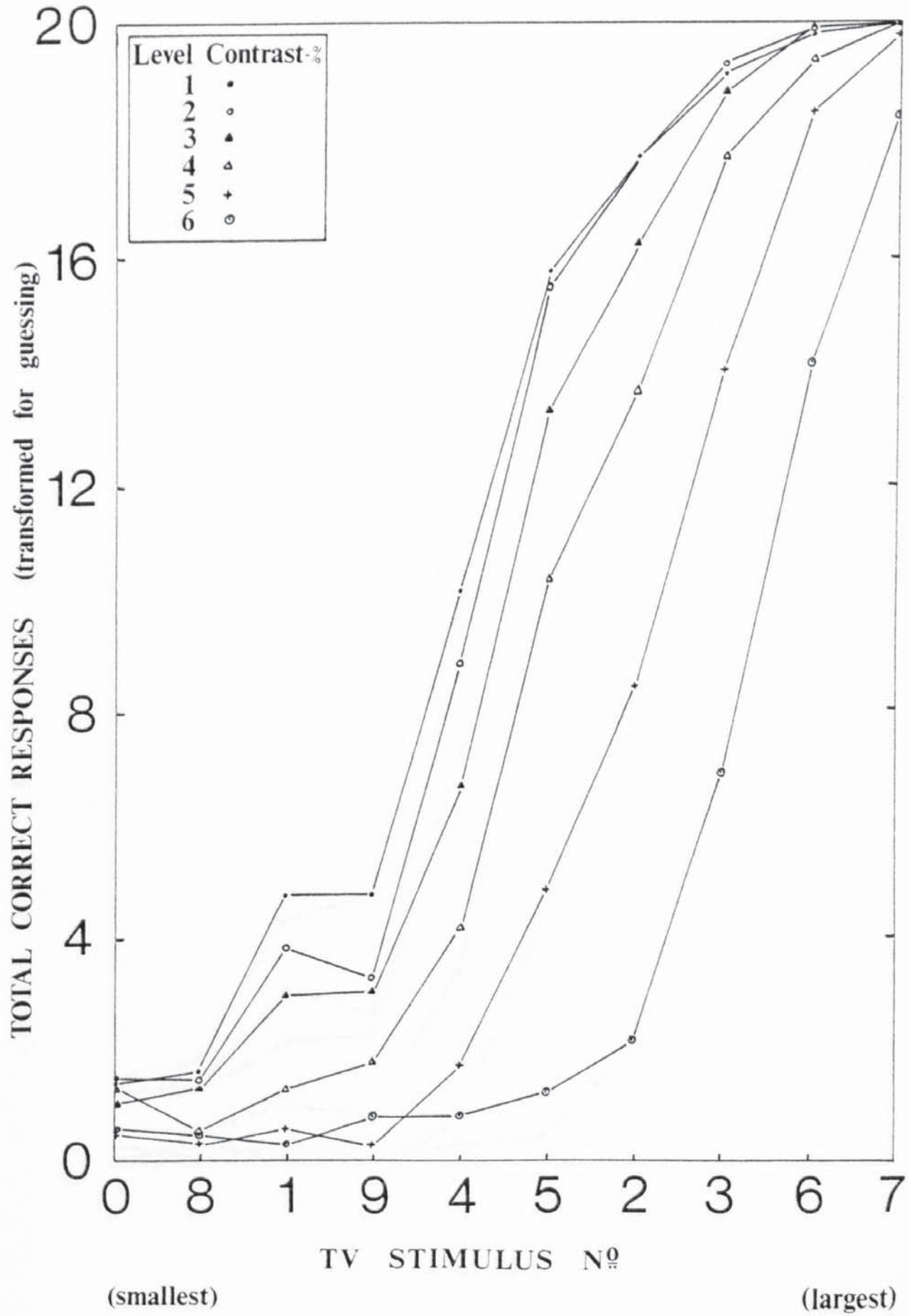
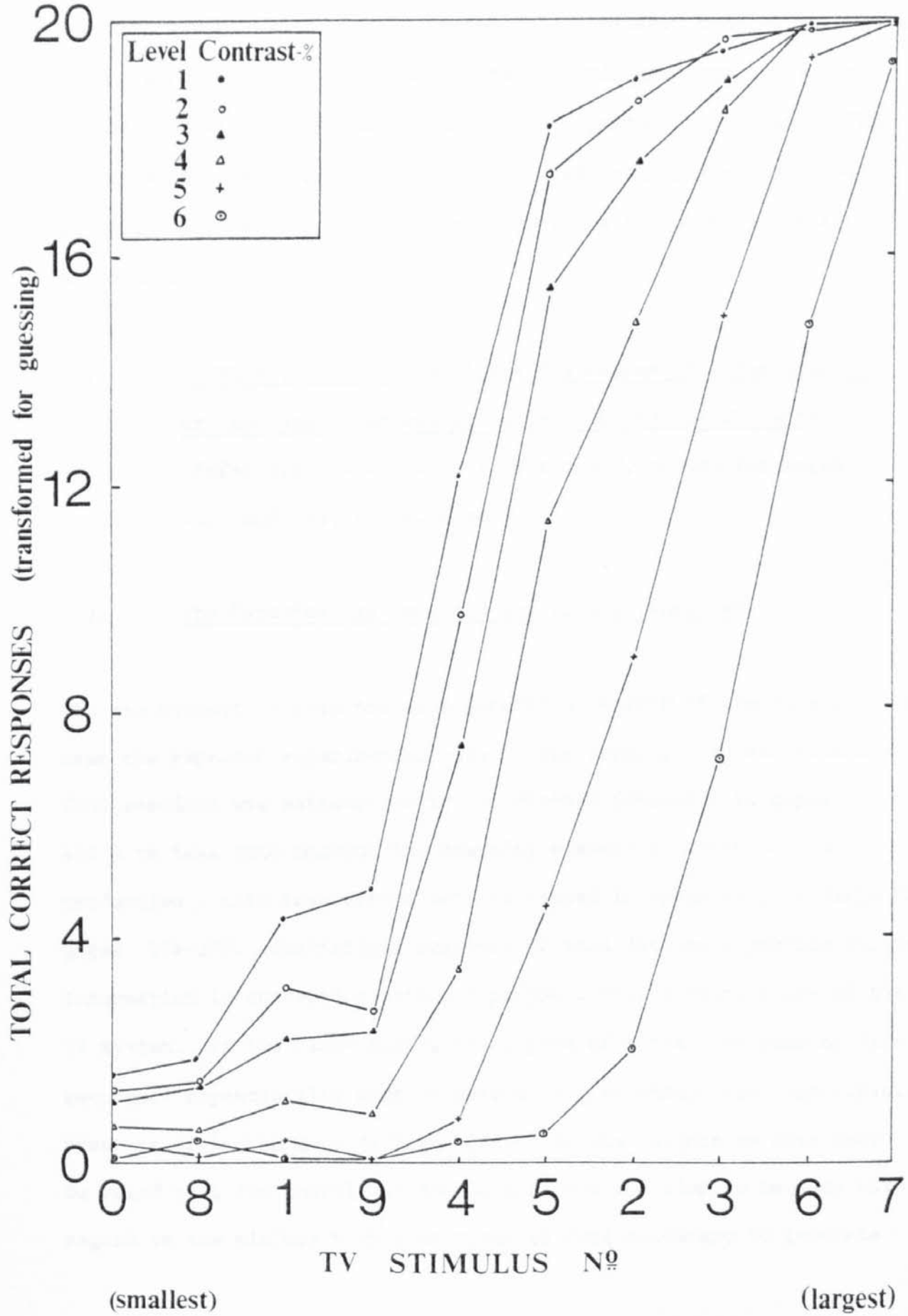

Level Contrast-%
1
2
3
4
5
6
20
16
12
8
4
0
TOTAL CORRECT RESPONSES (transformed for guessing)
0 8 1 9 4 5 2 3 6 7
TV STIMULUS Nº
(smallest)
(largest)

FIG. 17B - N=10


Level Contrast-%
1 •
2 ○
3 ▲
4 △
5 +
6 ⊙
20
16
12
8
4
0
TOTAL CORRECT RESPONSES (transformed for guessing)
0 8 1 9 4 5 2 3 6 7
TV STIMULUS Nº
(smallest)
(largest)

168), irrespective (within limits) of the acuity levels as determined by conventional consulting room techniques, should be noted. It should also be apparent that the appearance of an ideal result curve would be one with a shallow lower tail joined to a similarly shallow upper tail by an approximately linear curve with a gentle gradient : i.e., a spread of subjective results would be the optimum arrangement. This point is considered further in Section 7.4A (page 183 et seq.) below, in conjunction with a computational procedure to quantify visual performance.

7.2 STUDY No. 2 : To Investigate the Degree of Repeatability of the Data Generated by Subjects Using the TV System

(Refer also to Sections 5.2B and 6.2, commencing pages 121 and 148, respectively)

7.2A The Experimental Data and Statistical Analyses

The raw subjective response data generated by each of the five subjects over the repeated experimental runs in the morning (AM) and afternoon (PM) sessions was mathematically transformed (Appendix V, pages 426-430) to take into account the guessing element involved in its production : this transformed data is listed in Appendix II : Table 22, pages 274-279. Statistical analysis of this data must provide further information in connection with the proposed future routine use of the TV system. In the first place, the degree of subjective scoring (i.e., response) repeatability must be determined; secondly, the (undesirable) presence of learning or fatigue effects in the subjective data must be ruled out; and thirdly it should enable a decision to be made with regard to the minimum number of repeated runs necessary to generate

accurate and reliable data with the system.

To assess the degree of repeatability of subjective response, a determination of the Pearson product-moment correlation coefficient, r, (Appendix VIIC, pages 457-458) was made between the subject's responses (scores) to the repeated cycle of ten stimuli over ten runs with the TV system in the AM and PM sessions. The results of this analysis are given in Table 12 (page 171).

To investigate the possible existence of systematic variations within the data generated by subjects using the TV system, this same selection of individual and group results was then subjected to Student t-tests for correlated samples (non-directional or two-tailed) (Appendix VIIA, pages 453-454). The results of these analyses are summarized in Table 13 (page 172).

The procedure used to determine the minimum number of repeated runs (under constant experimental conditions) necessary to produce reliable data with the TV system was similar to that described by Fry and Enoch (1959) who, in turn, had based their approach on a design outlined by Tiffin and Rabideau (1955). The analysis used the available data generated by the five subjects on the two occasions (9.00 a.m. and 4.00 p.m.) upon which they undertook sequences of ten repeated runs under identical test conditions. The procedure was that the total value of the correct responses (transformed scores, corrected for guessing) over the first run of the AM session was correlated (for each of the five subjects in turn) with the total value of the correct responses over the first run of the PM session. After completing that correlation, the total number of correct responses over the first

Table 12: STUDY NO. 2 - Repeatability of subject scoring:

Summary of Pearson product-moment correlation coefficient (r) values AM and PM testing on same day (analysis undertaken on data corrected for guessing).

Refer to Appendix II: Table 23, pages 280-281.

	SUBJECT NO.					Group
	1	2	3	4	5	N=5
Pearson r	0.988	0.982	0.978	0.973	0.985	0.998
Level (df = 8)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

Table 13: STUDY NO. 2 - Reliability of subject scoring:

Summary of Student t-ratios, two-tailed testing of correlated samples (analysis undertaken on data corrected for guessing).

Refer to Appendix II: Table 24, pages 282-283.

	SUBJECT NO.					Group N=5
	1	2	3	4	5	
Student t	-0.252	0.148	1.120	-0.235	2.204	1.203
Level (df = 9) (*df = 49)	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05*

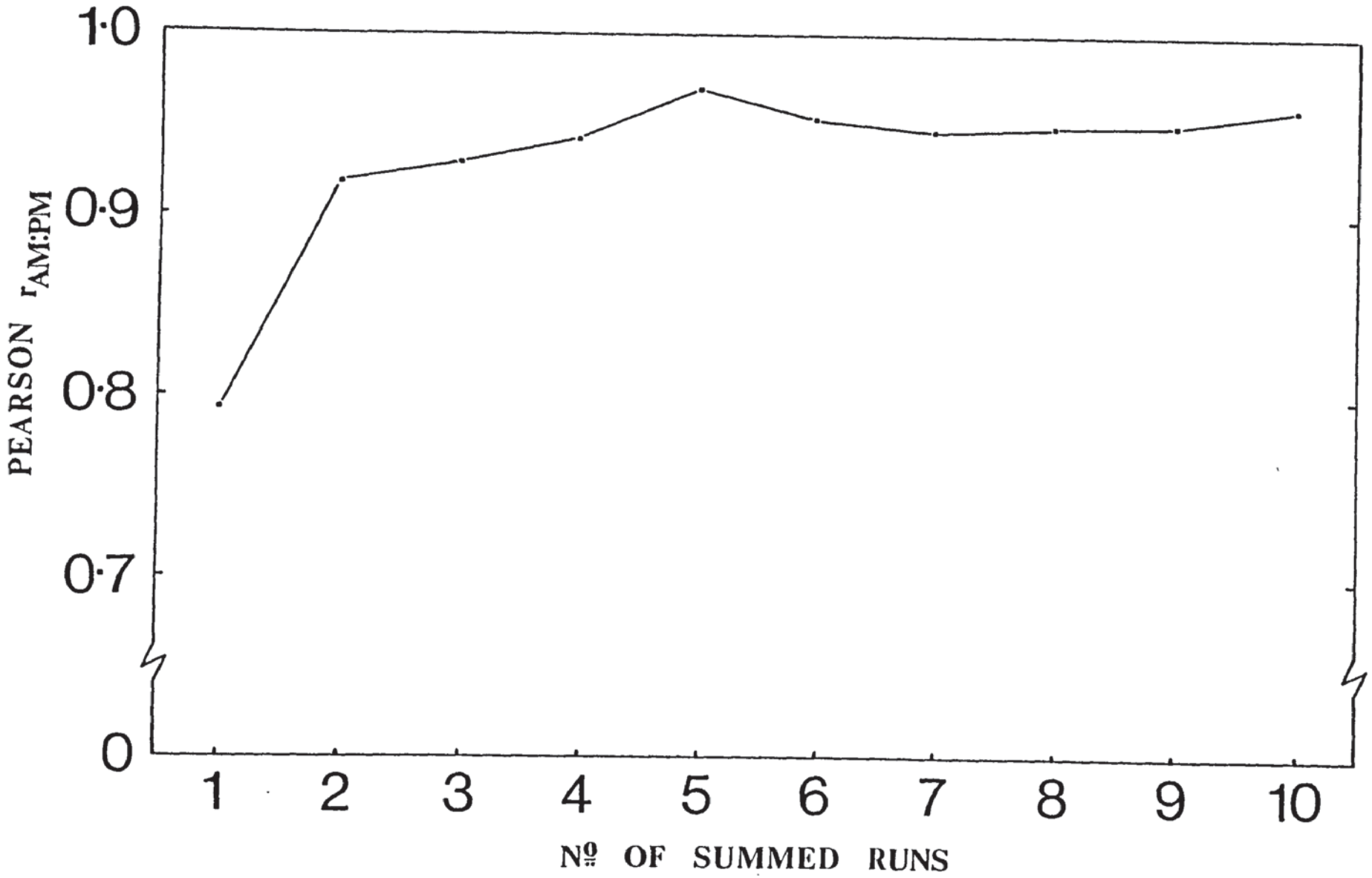
Table 14: STUDY NO. 2 - To establish the minimum necessary number of repeated runs : total correct scores for each of the five subjects computed from the 1st (only), 1st and 2nd, ..., 1st +....+ 10th runs (all data corrected for guessing), and the Pearson product-moment correlation coefficients (r am:pm) between the two experimental visits.

Subject No.	Visit	NO. OF SUMMED RUNS 1	2	3	4	5	6	7	8	9	10
1	am	53.33	116.00	172.00	235.33	302.66	363.99	413.99	475.32	530.65	590.65
	pm	63.33	125.99	189.32	252.65	310.65	369.98	429.31	479.31	537.31	591.98
2	am	57.33	114.66	169.99	220.66	274.66	325.33	384.66	443.99	502.61	559.28
	pm	52.67	110.67	166.67	224.00	286.67	340.67	394.67	451.34	501.34	547.34
3	am	50.67	97.34	150.01	196.68	246.01	291.34	348.67	399.34	447.34	496.67
	pm	51.33	102.00	154.67	196.00	242.00	279.33	328.00	372.67	416.00	460.00
4	am	40.00	85.33	124.66	175.99	220.66	283.33	330.66	379.66	426.99	484.99
	pm	46.00	90.00	134.00	185.33	225.33	282.66	332.66	387.99	439.32	489.99
5	am	69.33	141.33	205.33	272.00	344.67	419.34	490.01	558.68	624.01	692.68
	pm	64.67	128.00	192.67	255.34	324.67	390.00	458.67	516.67	580.00	642.00
r am:pm		0.793	0.916	0.928	0.942	0.968	0.953	0.947	0.949	0.951	0.960
Level(df=3)		$p>0.1$	$p<0.05$	$p<0.05$	$p<0.02$	$p<0.01$	$p<0.02$	$p<0.02$	$p<0.02$	$p<0.02$	$p<0.01$

FIGURE 18: STUDY No. 2 - To establish the minimum necessary number of repeated runs : a graphical representation of the obtained Pearson product-moment correlation coefficients ($r_{AM:PM}$) as a function of the number of summed runs.

(Refer to Table 14, page 173).

FIG. 18



and second runs of the AM session were summed and this value correlated with the corresponding data of the PM session. Correlations were made similarly for the summed data of runs one to three inclusive, and so up to runs one to ten inclusive. The results are presented in Table 14 (page 173), and Figure 18 (page 174) is a plot of the correlation coefficients ($r_{AM:PM}$) as a function of the number of summed runs.

7.2B A Preliminary Discussion of Results

The results of the several separate statistical analyses undertaken on the repeated data generated in the second study were all favourable with regard to the proposed routine use of the TV system.

In the first instance, as Table 12 (page 171) shows, the high level of statistical significance ($p < 0.001$: 8df) of the correlation coefficients associated with both the data of individual subjects and also for the group as a whole, is strongly suggestive of a high level of scoring repeatability on this type of apparatus.

Using the same mass of results, Student t-tests failed to demonstrate (Table 13, page 172) any statistically significant differences ($p > 0.05$: 9df, or 49df for group) in the data. This suggests the absence of both learning and fatigue effects in the data, the inference being that (as described in Chapter 6) providing there are always adequate operational instructions and the ample provision of trial runs and rest periods in association with data production, this will be the general case.

Thirdly, the sequential summing and correlating procedure adapted from Fry and Enoch (1959) enabled a decision to be reached regarding the minimum number of identical repeated runs necessary to produce reliable data with the TV system. The intention was to continue to increase the number of runs so long as this increased the value of the correlation coefficient. On the basis of the data presented in Figure 18 (page 174), it was decided to depend upon three runs of ten cycles (i.e., one hundred) stimulus presentations each. It is apparent from these results that five runs would produce the most reliable data. However, several further considerations, essentially of a practical nature, have to be taken into account. Each additional run would lengthen the experimental session by approximately six to eight minutes : to avoid subject boredom, to facilitate more investigations upon greater numbers of subjects, and to permit hourly scheduling of subject appointments, a monocular investigation ideally should not last for more than about twenty-five minutes. Thus, the usual situation of data collection on the two eyes of an individual, with trial runs and rests, would comfortably be accomplished within a sixty minute appointment. Considering the slight increase in reliability resulting from an increased number of runs, the decision to use three repeated runs as the basis for subjective data collection in future investigations was felt to be justified.

7.3 STUDY No. 3 To Investigate the Effect of the Incorporation of a Specific Ocular Excursion into the Operating Procedure

(Refer also to Sections 5.2C and 6.3, commencing pages 123 and 151 , respectively)

7.3A The Experimental Data and Statistical Analyses

In a similar manner to the procedure adopted for subjective response data analysis in the first study, the raw data generated by the five subjects over the course of the third study was collated, the scores for each run being corrected for guessing (Appendix V, pages 426 - 430). This data, as prepared for analysis, is listed in Appendix III : Table 25, pages 284-287. For handling in the statistical procedure, the transformed data was summed over the five runs undertaken at each of the twelve experimental sessions : the resulting lists of figures were subsequently punched onto cards in preparation for submission to the University's ICL 1900 computer. The application program (Ref : UA31; language ALGOL : vide Appendix VIA, pages 432-434) was again used, on this occasion to undertake a two-way analysis of variance with repeated measures (2) (completely crossed design) upon the prepared data.

Two analyses were undertaken. The first was upon data from all twelve of the experimental sessions (one spectacle lens and two soft contact lens visits, all stationary : nine soft contact lens visits, incorporating direct eye movements to each of eight peripheral fixation points in turn plus a special four-point eye movement); the second analysis was upon just the ocular excursion data generated over the

nine soft contact lens visits. The results of the analyses are summarized in Table 15A (page 179) : full sets of results are provided in Appendix III : Table 26, pages 288-290 . The trends demonstrated were identical in both cases.

With reference to the results of the first study (described in Section 7.1, page 162 et seq.), the level of stimulus angular subtense was again confirmed as a highly statistically significant factor, although in this third study it appeared to have no statistically significant interaction with any of the conditions prevailing at the experimental sessions.

For the sake of completeness, Tukey's (1953) a posteriori method for the multiple comparison of means (Appendix VIIB, pages 455-456) was undertaken upon this sole statistically significant factor : full results are provided in Appendix III : Tables 28A, 28B, pages 294-295. In summary, the results were similar to those found for this factor in the first study. All comparisons of means were statistically significant at the 1% level, other than comparisons of means between the two largest stimuli (numbers 6 and 7), and also between the two pairs of smallest stimuli (numbers 0 and 8, and 1 and 9), which were all revealed as not statistically significant ($p > 0.05$). However, in addition, three further comparisons of means for some of the larger stimuli (numbers 7 and 3, 6 and 3, and 2 and 3) were also not statistically significant ($p > 0.05$). This result was present in the analyses of both the total number of sessions (twelve : Table 28A, page 294), and in the ocular excursion sessions (nine : Table 28B, page 295) alone.

Table 15A : STUDY NO. 3 - The F-ratios obtained for the two main effect variables, and their interaction, when analysis of variance was undertaken on data corrected for guessing.

	Over all Group N = 5 : 12 visits	Over 9 eye Group N = 5 : movement visits
FACTOR		
A: EXPERIMENTAL SESSION	$F_{11,44}$ = 1.0513 p>0.1	$F_{8,32}$ = 0.5810 p>0.1
B: LEVEL OF STIMULUS ANGULAR SUBTENSE	$F_{9,36}$ = 126.4471 p<0.001	$F_{9,36}$ = 112.4234 p<0.001
INTERACTION		
A X B	$F_{99,396}$ = 0.9505 p>0.1	$F_{72,288}$ = 1.0952 p>0.1

Table 15B : STUDY NO. 3 - The F-ratios obtained for the two main effect variables, and their interaction, when analysis of variance was undertaken on data corrected for guessing (longhand calculation).

	Group N = 5 : Over 3 Stationary Visits		
FACTOR			
A : Experimental Session	$F_{2,120}$	= 2.6951	$p > 0.05$
B : Level of Stimulus Angular Subtense	$F_{9,120}$	= 149.2393	$p < 0.001$
INTERACTION			
A x B	$F_{18,120}$	= 0.3078	$p > 0.1$

7.3B A Preliminary Discussion of Results

It is in many ways surprising to find that, on the basis of these analyses, it is apparently immaterial whether or not an eye movement is undertaken by the subject prior to his making a response, let alone the particular axis of the excursion or even whether it is a movement sequence.

A further observation arising from the results of this third study is that, on the basis of the multiple comparisons between the mean scores of the subject group (as calculated in connection with the analysis of variance procedure), the level of subjective response to the two pairs of smallest stimuli does not differ from that established in the first study. However, for some of the larger stimuli the level of response appears to have increased : since the two largest stimuli (numbers 6 and 7) were seen correctly by all of the subjects one hundred per cent of the time over the experiment, the inference is that the level of subjective discriminability has been improved by some experimental factor. The sub-group of ten subjects in the first study all recorded a $^{6}/_{4}$ level of binocular Landolt acuity when wearing their best spectacle correction, and the five subjects in this third study all recorded a similar monocular level of $^{6}/_{4}$ with an optimum soft contact lens. Can this apparent improvement be credited to the change to monocular conditions of testing; to the fact that an eye movement was undertaken before a subjective response was made (and that the presentation and interval times were necessarily lengthened to accommodate this feature); or, in combination with any of these features, that a soft contact lens was worn?

It is considered unlikely that the change from binocular to monocular testing conditions, of itself, would produce any marked change in the subjective facility of discrimination : indeed, a slight improvement in visual acuity level has been demonstrated when both eyes of a normal observer are used (Campbell and Green 1965b).

In the light of the rather negative results in connection with the undertaking of a specific eye movement prior to registering a subjective response, it is doubtful that the ocular excursion was the source of the variation. However, for completeness sake, a two-way analysis of variance‡ was undertaken upon the data generated by the five subjects over the course of the three stationary experimental sessions only, viz, the first visit (wearing best spectacle correction) and the second and twelfth visits (wearing optimum soft contact lens). The results of this analysis are summarized in Table 15B (page 180) : full results are presented in Appendix III : Table 27, pages 291- 292. The similar trend in these results to those previously presented in Table 15A (page 179) will be immediately apparent. The full results of Tukey's (1953) a posteriori analysis (Appendix VIIB, pages 455-456) are provided in Appendix III : Table 28C, page 296. These results again indicated an apparently increased level of subjective response to stimuli at the larger end of the dimensional scale. Since no eye movements were undertaken prior to subjective response in these three experimental sessions, the

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‡ Partly for reasons of convenience and partly as an academic exercise this procedure was, on this occasion, undertaken in a longhand fashion, using only a desk top calculator.

inference is that this result, peculiar to this study, cannot therefore be attributed solely to the undertaking of the ocular excursion.

The inevitable conclusion is that the difference must lie somewhere within the smaller group of subjects participating in this third study, very possibly in connection with soft contact lens wear.

7.4 General Discussion of Results and Recommendations with regard to the Routine Clinical Operation of the TV System

7.4A The Operational Variables

Flexibility of approach was intentionally designed into the TV system. Early informal trials with the system, against the background of the relevant literature (discussed in Chapter 3), had indicated that for routine use in a clinical environment a 'scoring' approach rather than assessments based upon response latency, for example, would be the most suitable avenue of development. A psychophysical means of testing was utilized (the method of constant stimuli, in conjunction with a forced choice response technique), with the result that when the subject's score ('corrected' for guessing) was plotted against the angular subtense (minutes of arc) of the corresponding stimulus detail variations on the typical sigmoid curve represented the subjective response data (vide Appendix V, pages 426-430). To facilitate quantification of results, a computer program (Ref: JP 2; language BASIC : vide Appendix VIB, pages 435-438) was written to undertaken a linear regression analysis (method

of least squares : vide Appendix VIIC, pages 457-458) upon the central linear portion of the curve through the appropriate experimental results. In this manner the stimulus and response data of an individual subject or of a group, over any number of runs, could conveniently be specified in terms of certain details associated with the gradient of the best straight line through the experimental data : viz, the spread or variability of results as indicated by the first standard error of estimate, and also the quantification of a threshold acuity level (vide Pointer et al 1980b, 1981).

The three sequential studies described in Chapter 6 were undertaken with the intention of establishing certain operating principles in connection with the proposed clinical use of the TV system, under conditions of good even room illumination, to routinely quantify an individual's visual performance. On the basis of the results obtained from this validation work, these several operating principles will now be discussed.

7.4Ai Presentation and interval times

The choice of the original presentation and interval times, from the selection of settings available, was determined before any formal experimental work commenced. As Section 4.3Avi (pages 104-106) has described, from a consideration of the relevant literature and several informal trials conducted by the present author, setting 1.5 (2.22s : Table 5, page 105) appeared to represent a suitable stimulus presentation time; the need to manually record the subjective responses dictated the selection of setting 2 (1.87s) for the interval period. When a 15 degree eye movement was incorporated into the experimental

operating technique, both of these times were, of necessity, lengthened : the presentation time was increased to setting 2 (2.92s) and the interval time to setting 3 (2.65s). It should be remembered that the stated presentation time is by way of an absolute maximum presentation time : in operation the broken ring stimulus should never remain on the TV screen for this length of time. Provided that the subject follows the instructions that he has been given, he will have responded by depressing one of the four push buttons on his hand control box before the stimulus is automatically removed from the screen, even if the subjective response was felt to be largely a matter of guesswork.

The figures given in Table 5 (page 105) for the ranges of available presentation and interval times were obtained using a certain arrangement of data recording equipment. This equipment array was the prototype for a recording system devised to continuously monitor certain items of data generated in a study with the TV system which is to be described below (Chapter 8). With the availability of such a precise recording technique, the opportunity was taken to investigate whether there was any statistically significant variation, on a temporal basis, of the usual presentation (control setting 2) and interval (control setting 3) times. Such an assessment was undertaken, firstly, over the duration of a usual subjective data collection session (approximately three to four hours continuous usage); and secondly, over the course of several months regular usage.

Full results of this investigation are given in Appendix III : Table 29, pages 297-301. In summary, it may be stated here that,

provided the TV system was switched on for twenty to thirty minutes prior to any data collection, in order that it might attain its optimum operating level, (i.e., component temperature : vide page 147) these analyses did not reveal any evidence of statistically significant variations in the chosen presentation and interval times under either condition of investigation.

7.4Aii Direction of contrast

The figure-ground relationship has been consistently revealed as a non statistically significant variable in objective analyses of data generated with the existing system. This accords with the work of Seibert et al (1959) who found, using a sample group of normally-sighted individuals, that there were only minor differences in accuracy of identification for dark on light versus light on dark televised symbols. Under most conditions, dark on light symbols were identified only slightly more accurately (4.6%) than light on dark ones, this difference being slightly enhanced when the test symbol size was reduced. From a consideration of the limited literature in the field of televised symbol legibility, Shurtleff (1967) felt that for most frequently encountered values of ambient illumination (presumably conditions of daylight or usual good and even room illumination) the direction of contrast was probably not a major factor in legibility since the largest differences reported have been, as quoted above, only 4.6%. Under very high ambient illumination levels (presumably approaching a glare situation), where again dark on light symbols have been shown to be superior to light on dark ones, the accuracy of identification has been shown to be so poor that this condition would be unacceptable anyway. It would seem to be fairly

safe to assume that these findings may be carried through to the broken ring character used in the existing TV presentation system.

Subjective questioning revealed, after the responses of those persons who expressed no preference had been put aside, that there was an overwhelming preference for the presentation of dark broken ring stimuli on a lighter background, regardless of the actual level of contrast-per cent. The usual reason given by subjects for this choice was that they felt more confident responding to stimuli at this negative contrast. This may of course be merely an indication of conservatism on the part of the subjects, since they would all be aware that it is usual optometric consulting room practice to use dark letters on a light ground to assess visual acuity : in addition, a number of road and other signs in common experience appear thus. Since data analysis revealed that there was apparently no statistically significant difference in performance under the two conditions, this point also illustrates the comment made by Lythgoe (1932) that "...the judgement passed by the subject on his own performance is not of much value".

In the absence of conclusive guidance, not only from the literature but also from the data generated using the system itself, an arbitrary decision was made to utilize negative contrast (i.e., dark stimuli on a lighter background) in all future work. Aside from minimizing the possibility of any irradiation (halation) effects, this has the advantage of being the more conventional approach (cf., the conditions of presentation of the Snellen or Landolt optotypes, as specified in B.S. 4274 : 1968 "Test Charts for Determining Distance Visual Acuity").

7.4Aiii Level of contrast-per cent

This consistently statistically significant variable requires some consideration. As can be seen from Figure 17 (page 168), a family of sigmoid curves represented the subjective results obtained at the various contrast control settings. The two highest control settings 1 and 2 (55.02% and 42.81%, respectively : Table 4, page 99) produced similar curves over the greater part of their length, a point to be expected from the Tukey analysis (as discussed in Section 7.1A, pages 165-166); in the sub-group with the uniform acuity level (Figure 17B, page 168B)the gradients of the central portions of the curves were steeper, with a pronounced upper tail. Thus, at either of these contrast settings, sensitivity was lost for higher levels of stimulus angular subtense. The reverse was true of the two lowest control settings 5 and 6 (9.91% and 7.80%, respectively), where sensitivity was very poor for the lower levels of stimulus angular subtense. In addition, administration of the test procedure proved difficult at these latter two contrast settings; the stimulus was so faint that, with the smallest broken rings (in the absence of any cues) the subject was uncertain as to whether a stimulus was being presented or not. This uncertainty, coupled with a certain amount of pessimism with regard to the poor results that the subject felt that he was registering, resulted in a fair amount of subjective resistance to the use of either of these contrast levels.

With reference to the two mid-range control settings 3 and 4 (35.62% and 19.99%, respectively), it was decided that setting 3 was the optimum single choice for operation of the TV system. Whilst both of the experimental curves at the mid-range settings identified

discrete subjective response levels for the variously-sized stimuli (other than for the two largest, viz, numbers 6 and 7), the curve obtained at setting 3 distinguished between the two pairs of smallest stimuli (viz, numbers 0 and 8, and 1 and 9), thereby producing a maximum number (seven) of discrete data points in the case of both various and uniform visual acuity groups. This establishment of several mutually-exclusive levels of subjective data production was a desirable feature in connection with the linear regression analysis devised to quantify threshold acuity (Appendix VIB, pages 435-438).

7.4Aiv Levels of stimulus angular subtense

Surveys of the literature concerned with optometric test symbols and vision testing (e.g., Bennett 1965), whilst in agreement that a geometrical rather than an arithmetical progression of stimulus sizes was the preferred approach, remained divided upon the question of the optimum progression ratio to be adopted. In the event, as reported in Section 4.3Aii (pages 90 - 96), the actual choice of stimulus sizes (i.e., the critical detail) in the work reported herein was something of a compromise, being governed by the dimensions of the smallest practical element on the TV viewing screen, viz, two scan lines. It was thus fortunate that the stimulus angular subtense proved to be a consistently statistically significant variable in the reported work. At the most discriminating contrast level (setting 3 : 35.62%) seven of the eight possible levels of stimulus angular subtense could be identified consistently from the subjective responses. At the regular viewing distance of 9.7m these data points were, in ascending level of angular subtense (minutes of arc) : cyclic stimulus number 0 and 8 (0.35); 1 and 9 (0.53);

4 (0.62); 5 (1.15); 2 (1.32); 3 (2.03); 6 (2.74) and 7 (4.15). The conclusion must be that, most especially in combination with contrast setting 3, this selection represented a reasonably discriminating range of test stimuli.

7.4Av Orientation of the TV stimuli and an assessment of subjective guessing bias

As described in Section 4.3Aiii (pages 96 - 97), the gaps in the broken ring stimuli were presented in the four cardinal positions only, viz, in either the top, bottom, left or right sides of the angular ring (as viewed by the subject in the mirror aperture). However, as part of the validation work with the existing system, two points were required to be clarified : firstly, was there any evidence of a machine bias towards the presentation of more stimuli in a particular configuration than others? - and secondly, did there exist an apparent subjective guessing bias, i.e., when the subject was uncertain of the precise orientation of the stimulus did he have a preferred direction of response?

In an attempt to answer these two questions, two series of results, obtained under similar experimental conditions, were abstracted from the mass of data produced by the third study. Series I comprised the stimulus and response data obtained for the five subjects over five sequential runs at the first visit (wearing the best spectacle correction before the dominant eye) : Series II comprised similar data gathered at the twelfth visit (wearing the optimum soft contact lens on the same eye). From the relevant data recording charts it was possible to total, for each of the four orientations, the number

of stimuli presented to each subject. These results are presented in Appendix III : Table 30A, pages 303-304), along with summary tables relating to the statistical analyses to be discussed below. The two series, representing sessions undertaken several months apart, would provide a check upon one another, since similar results in the statistical analyses would enhance the validity of the conclusions drawn with regard to the nature of stimulus presentation.

For both of the two series of stimulus orientation totals under consideration here, one-way analyses of variance (Table 30B, pages 305-306) produced statistically significant results ($p < 0.001$) : subsequent Tukey analysis of the means in both cases then located the point of significance (at the 1% level) at the break uppermost orientation (Table 30B, pages 305-306). Having established that a stimulus presentation bias existed, two two-way analyses of variance were next undertaken upon a cyclic breakdown of the same data, to investigate whether the overall machine presentation bias could be linked with any of the ten levels of stimulus angular subtense. Again for both series of data, as anticipated, stimulus orientation was revealed (Table 30C, pages 307 - 310) as a statistically significant variable ($p < 0.001$) but level of stimulus angular subtense, of itself, was not statistically significant at any probability level. There was, however, a statistically significant interaction between the two variables (Series I : $p < 0.001$, and Series II : $p < 0.01$) which required further investigation. Tukey analyses located the point of significance (at the 1% level) again at the break uppermost orientation (Table 30C, pages 307 - 310). Two further one-way analyses of variance were therefore undertaken, this time just on the data for level of stimulus angular subtense under the break uppermost condition.

Marginally statistically significant results were achieved (Series I : $p < 0.025$, and Series II : $p < 0.1$; Table 30D, page 311), but no statistically significant results were achieved upon subsequent Tukey analyses of the means.

The overall conclusion must be that whilst there was an unfortunate tendency for the existing TV system to present more stimuli in the break uppermost orientation than in any of the other three positions, this bias was fortunately not linked with any of the levels of stimulus angular subtense (i.e., with stimulus size or number in the presentation cycle). This being the case, an inference could be that, as far as the subject was concerned, he was presented with a completely random task at each televised stimulus presentation.

This machine bias was not pointed out to the subjects, and they were not directly questioned as regards this point. However, it should be noted that over the course of the work with the TV system none of the subjects volunteered the information that they had noted that there were more broken ring stimuli with their break uppermost than in any other configuration. A truly objective indication as to whether this was indeed the case would only be provided by an analysis of subjective responses over the course of the two experimental series just discussed.

As discussed by Pointer et al (1980a), the literature contains references to the presence and direction of a subjective guessing bias in association with the use of the classic Landolt broken ring in visual acuity assessments. Prince and Fry (1958) have devised an equation which makes an allowance for subjective guessing in the

computation of the number of times that the break in the stimulus is actually seen. This equation can be applied in turn to the subjective data relating to the totalled responses to the break up, down, left and right presentations. If it is accepted that:

$$N_c = N_s + \frac{(\bar{N} - N_s)}{4} \quad *$$

where, for a given direction:

$\bar{N}$ represents the total number of times that the break in this direction is called,

N_c represents the number of times that the break in this direction is called correctly,

N_s represents the number of times that the break in this direction is actually seen,

then:

$$N_s = \frac{4N_c - \bar{N}}{3} \quad .$$

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* The assumption of a 1 in 4 (25%) chance of guessing correctly is no doubt an over-simplication because there must be instances when the subject can detect that the break is not up or down, for example, but cannot tell whether it is left or right.

The three quantities $\bar{N}$, N_c and N_s were determined using the same two series of experimental data (Series I : best spectacle correction; Series II : optimum soft contact lens) which had been utilized in the previous investigation of the possibility of the existence of a machine bias (vide supra, this Section, pages 190 -191). These results are tabulated in Appendix III : Table 31, pages 312 - 314, and the relationships of the three quantities are represented graphically in Figure 19 (page 195). There was a striking similarity between the individual results of the five subjects, regardless of which series was considered : consequently, for clarity and conciseness, the group (N=5) results are presented in Figure 19 (page 195) as being representative of the results of the individual subjects.

The first point to be noted is that the established bias of the machine presentation mode is reflected in the results as displayed in Figure 19 (page 195) : the subjective responses to break left or right are seen to be fairly well balanced, whereas the break up response curves are clearly elevated at the expense of break down.

The working hypothesis for the interpretation of these results was that if there did indeed exist a complete randomness of choice in the event of subjective uncertainty (as for example, might be the case with the smaller stimuli), then there would be an approximately equal separation (notably at the lower levels of stimulus angular subtense) between the total number of responses (correct plus incorrect) in a given orientation (curve $\bar{N}$) and the number of times which that orientation was called correctly (curve N_c).

This certainly is revealed to be the case : the relationships of

Figure 19: To assess the possibility of the existence of a subjective guessing bias associated with the generation of data using the TV system. (A machine bias towards presentation of stimuli with break uppermost has previously been established). (after Prince and Fry, 1958).

Figure 19A: Summed data for the group of subjects (N = 5) - best spectacle correction before dominant eye alone: 6/4

Figure 19B: Summed data for the group of subjects (N = 5) - optimum soft contact lens upon dominant eye alone: 6/4

For explanation of symbols ($\bar{N}$, N_c, N_s) refer to text; Section 7.4Av, pages 192-193.

FIG. 19A- SPECTACLE LENS

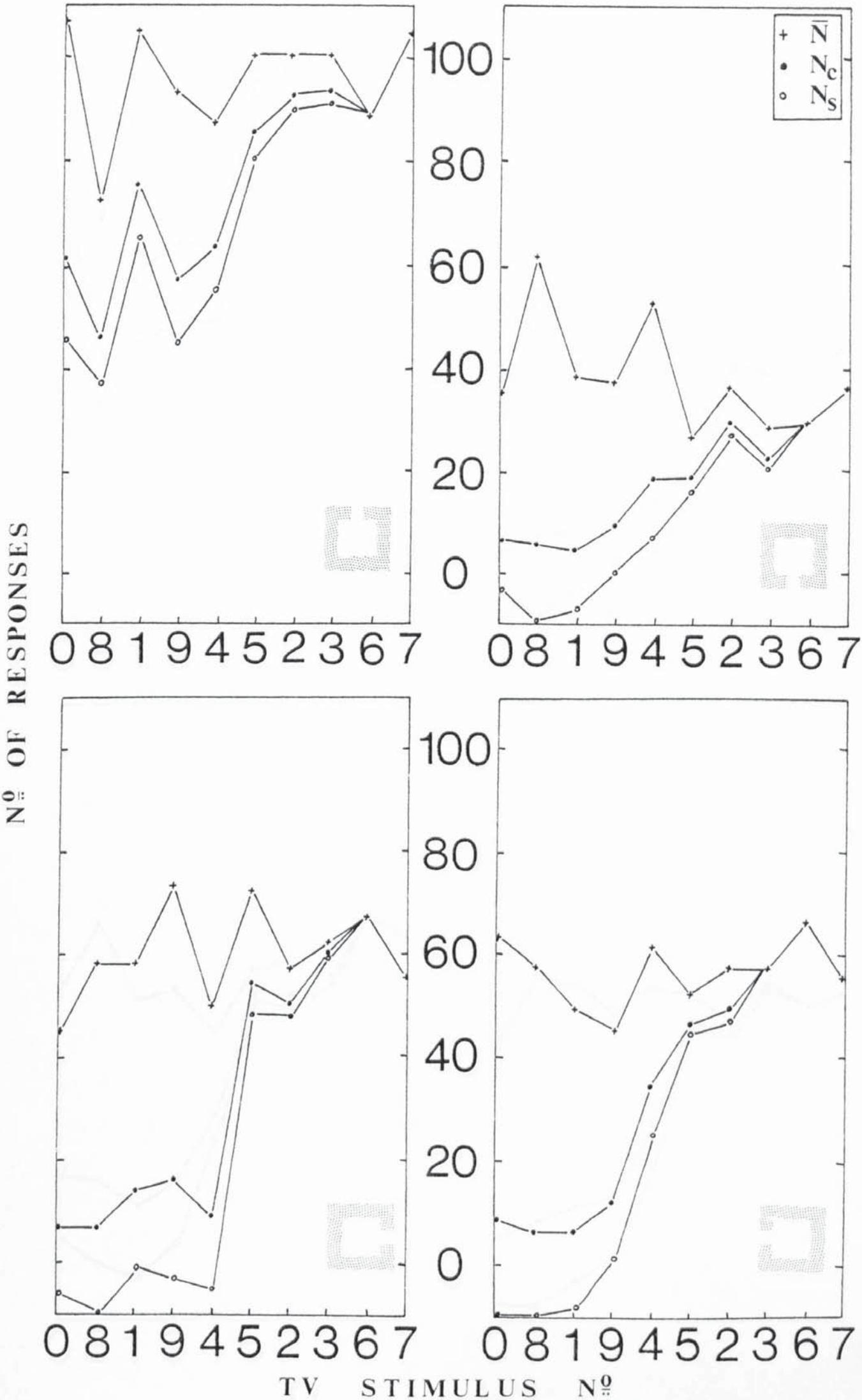
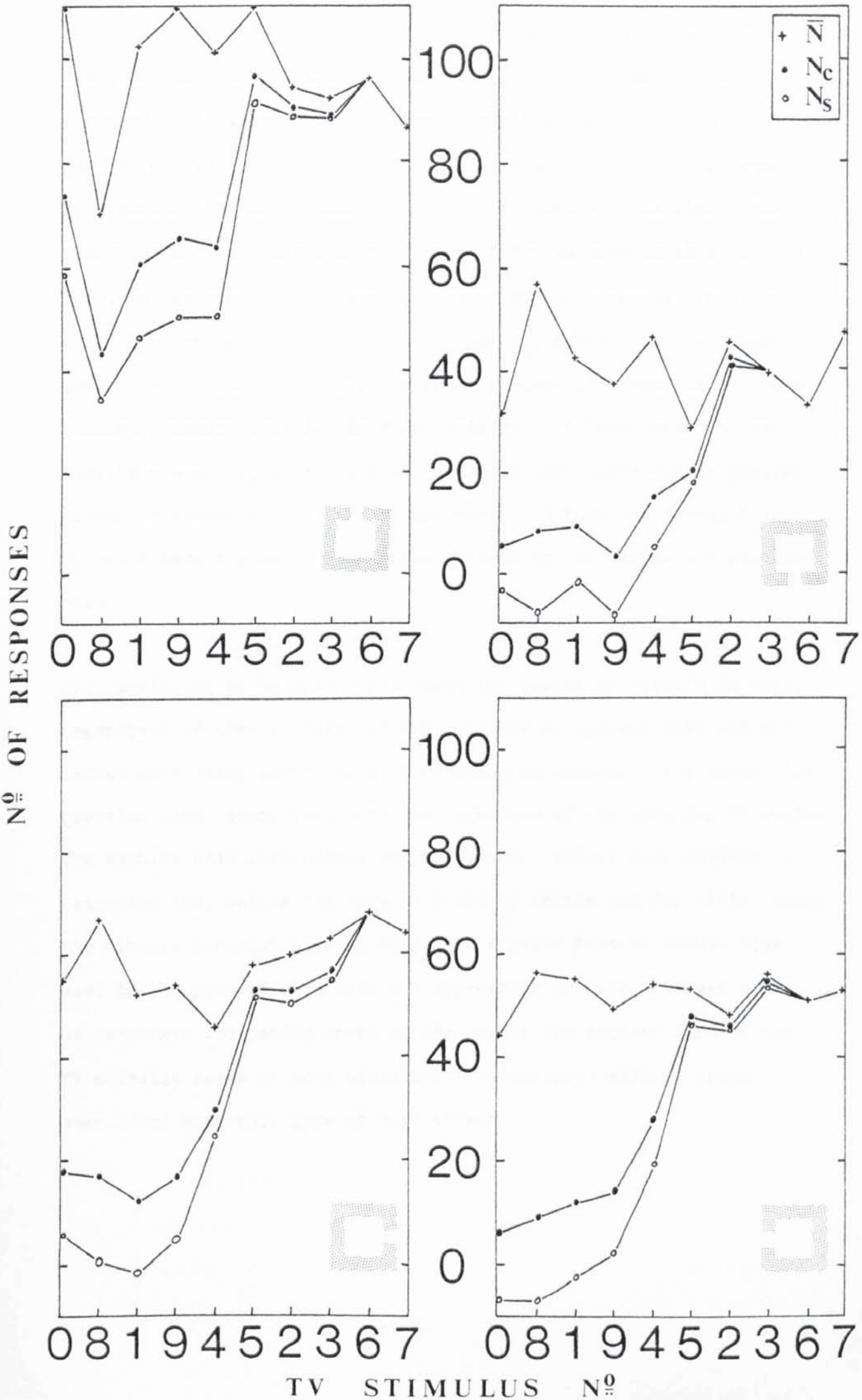


FIG. 19B- SOFT CONTACT LENS



the curves for results at break left and right, and also at break down, are all very similar. However, at break up there is an apparently close and regular relationship between the curves. This must surely be a consequence of the much higher incidence of break up presentations as a result of the established machine bias. More presentations can only mean that more of the guesses in this orientation, in the event of subjective uncertainty of response, are bound to be correct and thus the $\bar{N}$ and N_c (and N_s) curves will be brought into closer proximity, i.e., incorrect guesses are 'absorbed' by the machine presentation bias in this meridian. If this were not the case (for example, if the subject realized that there were a greater number of presentations in this one meridian) then the curves $\bar{N}$ and N_c would have a greater separation reflecting the subjective guessing bias.

The conclusion to be drawn from these two series of results is that, regardless of whether best spectacle lenses or optimum soft contact lenses were being worn, there is revealed no evidence of a subjective guessing bias associated with the operation of the existing TV system. The machine bias fortunately has no apparent effect upon subjective responses and, unlike the results found by Prince and Fry (1958) using the classic circular Landolt ring, the angular form of broken ring used in the present work does not apparently promote a larger number of responses indicating break to the right; the angular form of the TV stimulus seems to have minimized the 'cultural effect' often associated with this type of test object.

7.4Avi Repeatability and reliability of subjective response data

The high level of statistical significance of the Pearson product-movement correlation coefficients (both for individual subjects and for the group as a whole) quoted in Section 7.2A (Table 12, page 171) is strongly suggestive of a high level of subjective scoring repeatability with this system. It should be noted, however, in connection with the linear regression program devised to quantify threshold acuity (Appendix VIB, pages 435-438) that this scoring repeatability does not mean that a particular subjectively-determined Landolt visual acuity level will correspond to a particular gradient of regression line through the subjective response data, nor vice versa. As a consequence of the psychophysical method of testing, in conjunction with the other experimental variables, such a direct relationship would not be expected. This inter-subject variability has frequently been remarked upon in this form of investigation : a recent pertinent example has been provided by Arden (1978) in the operation of his grating test.

Further analysis of this same repeatability data could not demonstrate the presence of either a learning or a fatigue effect in the data (Table 13, page 172). It was thus reasonable to assume that provided there was adequate provision of operating instructions, trial runs and rest periods, such effects would not interfere with the validity and precision of data generation.

Finally, as has been described in Section 7.2B (Table 14 and Figure 18, pages 173 and 174 respectively), it was decided that three runs, each comprising one hundred stimuli (ten cycles of the ten stimuli),

would provide a satisfactory basis for data collection. A balance has to be struck between the reliability of the data generated and the degree of sustained subjective co-operation. Three runs, of perhaps twenty to twenty-five minutes duration, would mean that both eyes of an individual subject could be assessed in an appointment lasting approximately one hour, an optimum attention span.

7.4Avii The incorporation of a specific ocular excursion into the experimental operating procedure

Despite the rather negative results of the third validation study (discussed in Section 7.3B, pages 181- 183), it was decided to incorporate a specific ocular excursion into the experimental operating technique. The 15 degree eye movement, although controlled, was felt to more accurately simulate 'real life' viewing conditions, especially in the context of soft contact lens wear. In the earlier studies, the investigator had noted a tendency for subjects to stare fixedly at the viewing aperture, clearly suppressing the inclination to blink : such a modification to normal viewing would be undesirable when soft contact lenses were being worn.

Several of the subjects involved in the third study volunteered the information that the incorporation of an eye movement made the visual task more interesting than when merely viewing straight-ahead, and that their response-making felt more positive. The sounding of the auditory cue confirmed that a stimulus was about to be presented. With straight-ahead viewing, uncertainty apparently sometimes arose in connection with the presentation of the smaller stimuli, only the established rhythm of stimulus-on and response-off

being available to guide the subject. Sometimes there was erroneous button pressing, subjective confusion and uncertainty, and an overall feeling of subjective dissatisfaction with the registered response : data collection on that run then had to be re-started. With the incorporation of a cue, such uncertainty could not arise.

A single 15 degree movement was preferred to the undertaking of a multiple one. The four-point movement investigated in the third study required the provision of a longer interval time for its accomplishment, resulting in a rather protracted run and thence experimental session. With a multiple movement, unless a more complex cue arrangement could be incorporated, there was also no real control over the time that the subject spent viewing each individual fixation point. As the subsequent statistical analysis showed, a multiple excursion was an unnecessary embellishment to the operating technique.

It was decided, somewhat arbitrarily, that when the right eye of the subject was being used fixation point number 6 (refer to Figure 15, page 126) would be viewed, and when the left eye was being tested the symmetrically-placed fixation point number 4 would be viewed. Thus, irrespective of the eye under investigation, when the cue sounded the 'active' path of the visual axis would be up and towards the mid-line to view the mirror aperture 2.5m distant, in readiness for the presentation of the broken ring stimulus. When a response had been made, a 'relaxation' movement of the visual axis down and away from the mid-line would take place, to restore steady fixation to the spot some 15 degrees away from the point which had just been viewed on the mirror. In all work the delay time on the auditory cue device would be maintained at 1.50s (i.e., 1.50s will elapse after the point

of response to a given stimulus before the auditory cue sounds to initiate the eye movement in preparation for the presentation of the next stimulus).

7.4B The Routine Clinical Operation of the TV System

On the basis of the validation studies, certain guidelines have been established with regard to the operating conditions for the proposed routine clinical use of the TV system. As regards control settings, the maximum stimulus presentation time should be fixed at control setting 2, 2.92s, and the inter-stimulus interval time should be set at control setting 3, 2.65s. Under conditions of good even room illumination the stimulus contrast should be in a negative direction (i.e., dark stimuli on a lighter background) and set at control setting 3, - 35.62%. A specific 15 degree ocular excursion should be undertaken prior to each stimulus presentation, with a constant 1.50s delay on the sounding of the auditory cue device. There should be the provision of adequate operating instructions, trial runs and brief rest periods, to ensure repeatability and reliability of subjective response data generated over three sequential monocular runs comprising one hundred stimuli each.

Once the data for the individual runs has been subjected to the correction for guessing transformation, the manner of data handling will of course vary with the experimental aims. However, where an indication of visual performance with the particular refractive aid worn by the subject during data generation is required, the utilization

of a linear regression procedure** to match up stimulus (i.e., the angular subtense of the stimulus detail, in minutes of arc) and response data should be considered. This would permit the condensing of the data to a statement of threshold acuity level, along with an indication of the magnitude of the variables associated with the establishment of the best straight line through the subjective results (i.e., the gradient, the first standard error of estimate involved in its determination, and the Pearson correlation coefficient). A computer program has been prepared, Ref: JP2 (listed in Appendix VIB, pages 435 - 438), specifically to facilitate such an analysis : illustrative examples of its use have been provided by Pointer et al (1980b, 1981).

To summarize, the satisfactory validation of the TV system's operational variables (as investigated in the first, second and third studies) has led to the establishment of a procedure for the routine clinical assessment of visual performance. As the next stage of the work it was proposed to utilize the TV system in a study of visual performance aspects of soft contact lens wear.

** Data utilized should be other than 0% and 100% correct, in order that the best fit straight line will be a close approximation to the linear portion of the sigmoid curve.

CHAPTER 8

THE VISUAL PERFORMANCE OF PERSONS ADAPTING TO SOFT CONTACT LENS WEAR

CHAPTER 8

THE VISUAL PERFORMANCE OF PERSONS ADAPTING TO SOFT CONTACT LENS WEAR

8.1 STUDY No. 4 : To Investigate the Possible Adoption, by Persons Adapting to Soft Contact Lens Wear, of a Strategy to Optimize their Visual Performance

(Refer to Section 5.3, commencing page 133)

8.1A Introduction and Details of Subject Group

The incentive offered to attract potential subjects for participation in this fourth study, rather than cash payments, was the promise of the provision of Hydron Europe standard thickness daily wear soft contact lenses, plus an introductory pack of the appropriate solutions and twelve months aftercare, for a modest fee (£60). A portion of this fee (up to £30, at the discretion of the investigator) would be refunded if the times and dates of all data collection visits as laid down and agreed by both subject and investigator before the study commenced, were strictly adhered to. This represented an attractive proposition since, in return for a total of seven data collection visits (each lasting in the region of one hour), the subject would be ethically prescribed a pair of soft contact lenses to his prescription and individual fitting requirements, with aftercare provision, for a fee approximately twenty-five per cent of that charged for similar professional services by an ophthalmic optical

practitioner in private practice+.

The stated aim of this fourth study was to investigate the possible adoption of a particular strategy to optimize visual performance by a person adapting to soft contact lens wear. To satisfy this objective, it would be necessary to have a full and continuous record of a subject's responses to the succession of stimuli presented over each run that he undertook with the TV system, along with parallel information relating to response latency and eye-blink activity. Thus the features required of additional equipment were twofold: firstly, that it should be able to accommodate continuous recording of data over several channels; secondly, that it should have the facility to permit storage of this data until such time as analysis could be undertaken on it.

The provision of a system which recorded data on tape (either magnetic or paper) seemed to be the ideal solution in this case.

+ It should be noted that over a previous period of approximately five years similar schemes involving the supply of soft contact lenses to volunteer subjects in return for the generation of experimental data had been run by workers in the Soft Contact Lens Research Unit, Department of Ophthalmic Optics, The University of Aston in Birmingham. This practice seemed to produce a reasonable number of interested volunteer subjects, and to date no complaints on professional or ethical grounds had been received from ophthalmic optical colleagues in private practice in the city centre locality.

The possibility of using electronic digital event counters or meters or, ideally, digital interval timers with integral thermal printheads, was investigated. However, the expense of such devices proved prohibitive in the context of the financial budget imposed upon the work. In addition, as a consequence of the low level of expert electronic and technical assistance available within the Department at the time that this work was being planned, problems immediately arose in association with both the construction of such equipment arrays and also with regard to the interfacing of the same to the electronic control circuitry of the existing TV system.

Thus, for technical and economic reasons, equipment already available within the Department had to be employed for the data recording and storage requirements of the proposed study. To this end, a reel-to-reel magnetic tape recorder and one, or possibly two, thermal pen recorders were available for unlimited use over the period when it was planned to run the project (late Spring and Summer, 1980). It was established that both of the thermal recorders (thermal pens in contact with an advancing roll of heat sensitive paper tape), because they were a few years old and had already experienced fairly heavy usage, would prove unreliable above about two hours continuous running. Since over the period of the proposed study the equipment would possibly be required to be switched on daily for several hours at a time, this option was clearly unsatisfactory. On the other hand, the reel-to-reel magnetic tape recorder was expressly designed for such demanding usage, and with four available channels it had effectively twice the data recording capacity of the thermal instruments.

Consequently, it was decided to interface the magnetic tape recorder

directly to the electronic control circuitry of the TV system (Figure 20, page 207) and also to the blink monitoring device (Figure 21, page 208). This work was carried out fairly readily by an electronics technician. At the same time the opportunity was taken to make a permanent modification to the blink monitoring apparatus as the result of some recent informal trials. As had been feared at the design stage, and indeed remarked upon in the discussion of the rationale of the design of this study (Section 5.3, pages 135-137), the unrestricted head movements of the subject during the course of a run with the TV system caused inaccuracies in the recording of the blink activity. A more homogeneous, local, light source was required to trigger the photocell. Thus, as previously suggested (pages 136-137) a miniature tungsten filament bulb, with its own low dc power supply (with rheostat control) was fixed in a metal sleeve on the same clip mounting as the photocell itself (Figure 22, page 209). Then, when the apparatus was clipped to the appropriate side arm of the trial frame, the restrictive neck of the metal sleeve produced a discrete, dim but homogeneous area of illumination on the glistening temporal conjunctiva of the subject's open eye under investigation. A blink intercepted the beam, the skin of the eyelid being much less reflective than the moist conjunctiva, and the photocell was triggered, i.e., one blink unit was recorded. In practice it was found that the light from the incandescent bulb could be very dim yet still trigger the photocell : this must have been because of the bright, glistening nature of the conjunctiva, coupled with the fact that the spot of illumination was constant regardless of head posture or movement. This, of course, was an advantage, rendering the light source a minimal distraction to the subject : indeed, several subjects volunteered the information that

FIGURE 20: Photograph of the equipment array (STUDY No. 4) facilitating the continuous recording of a subject's correctness of response data over an experimental run with the TV system

Key:

A — auditory cue device, with built-in loudspeaker and controls for selection of delay time (and own electrical power transformer)

H — subject's hand control box, with the four push-button indicators

TV — TV system

TR — Tandberg reel-to-reel magnetic tape recorder, in 'record' mode, interfaced directly to the electronic control circuitry of the TV system :

- Channel 1 - the sequence of presentations of the stimuli on the TV screen;
- Channel 2 - the temporal locations of the subject's responses (from whence the response latency data)

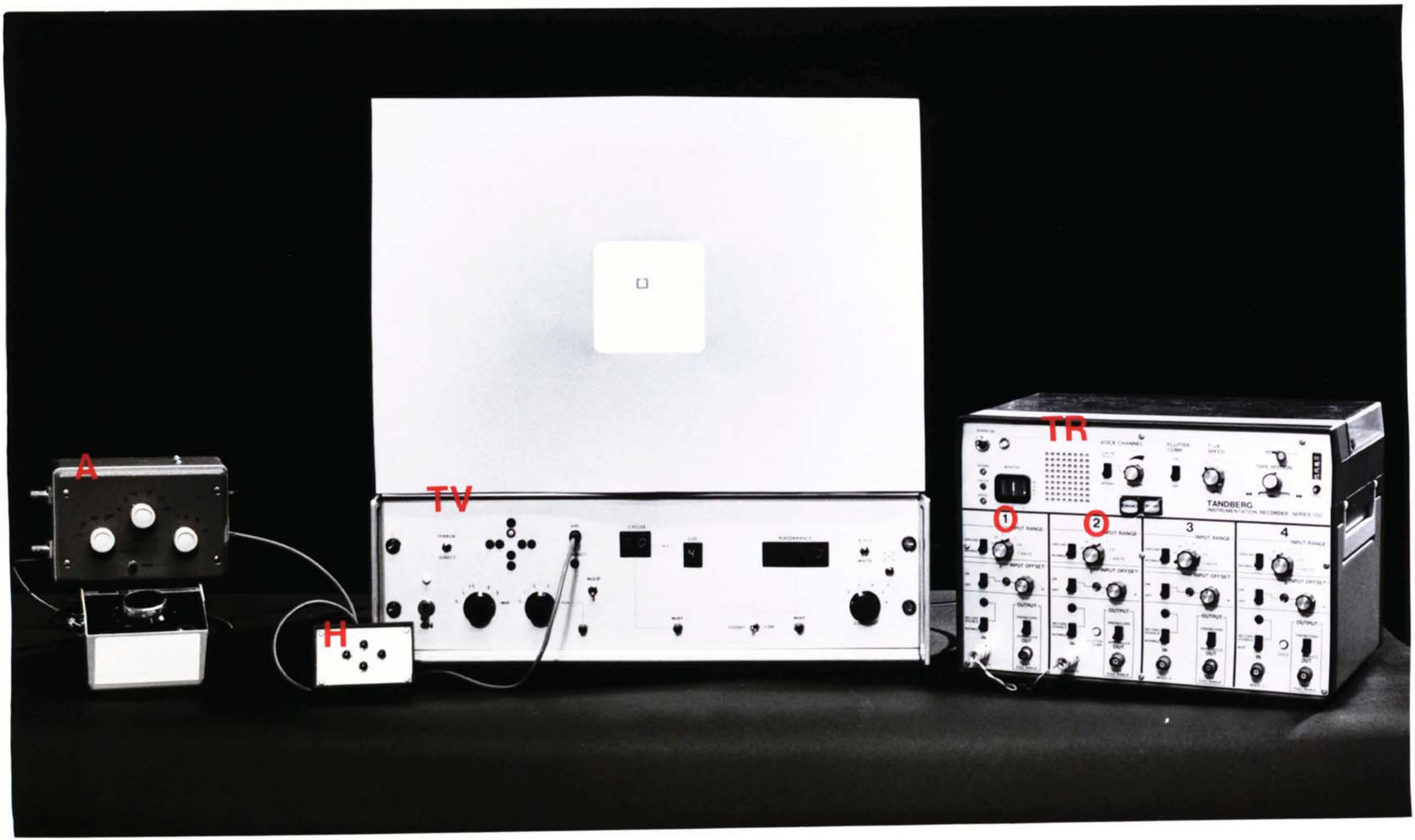

A
TV
H
TR
TANDBERG
1
2
3
4

FIGURE 21: Photograph of the equipment array (STUDY No. 4) facilitating the continuous recording of a subject's eye-blink activity over an experimental run with the TV system

Key:

B — blink monitoring apparatus attached to arm of adjustable optometric trial frame (vide Figure 22, page 209)

C — control box for the blink monitoring apparatus, with electrical power on/off switch, brightness intensity control for the light source, and digital event (blink) counter display

P — independent stabilized dc electrical power supply for the blink monitoring equipment

TR — Tandberg reel-to-reel magnetic tape recorder, in 'record' mode, interfaced directly to the blink monitoring equipment:

- Channel 3 - the temporal locations of the subject's eye-blink activity over a run with the TV system (before, during and after each stimulus presentation)

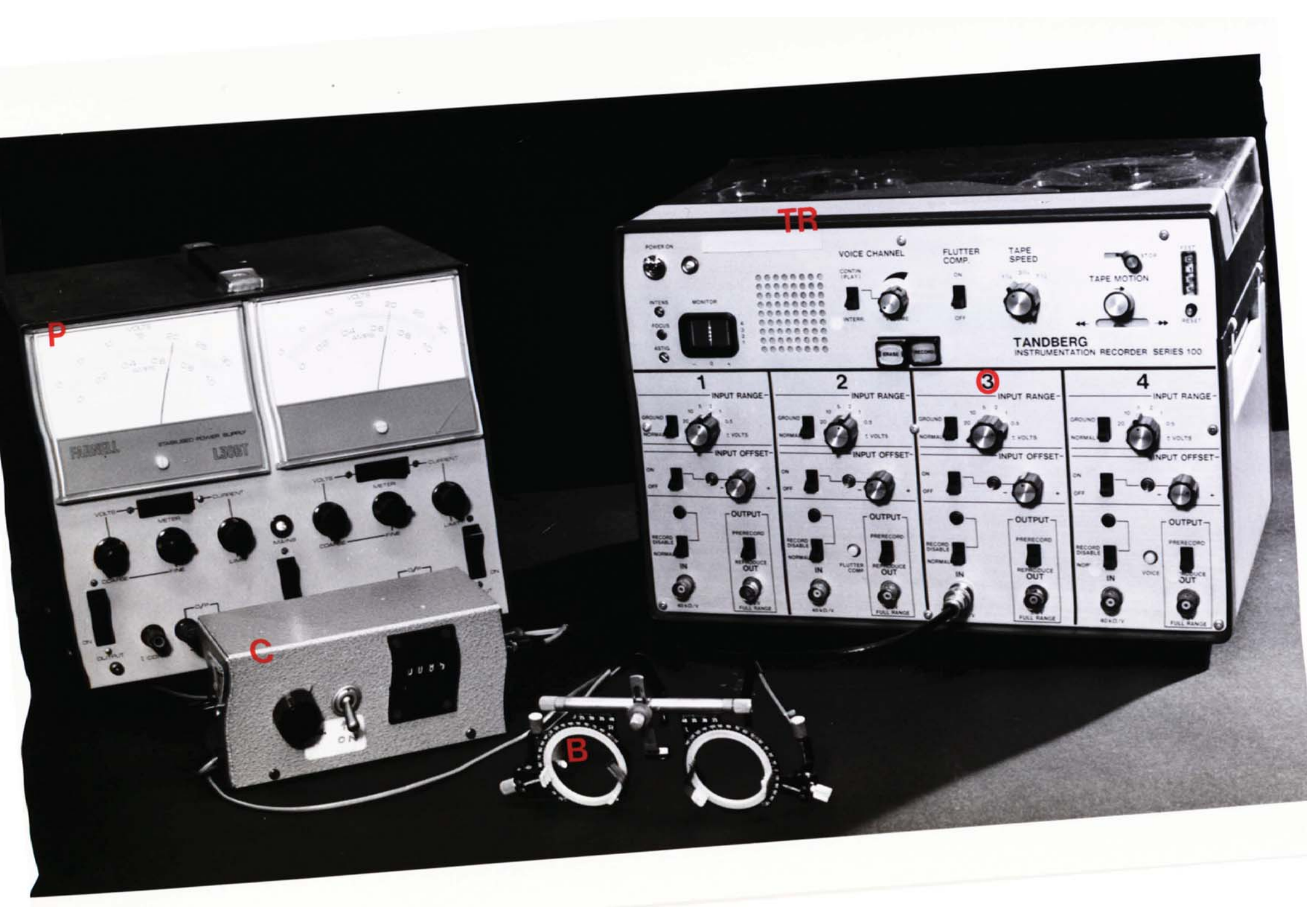
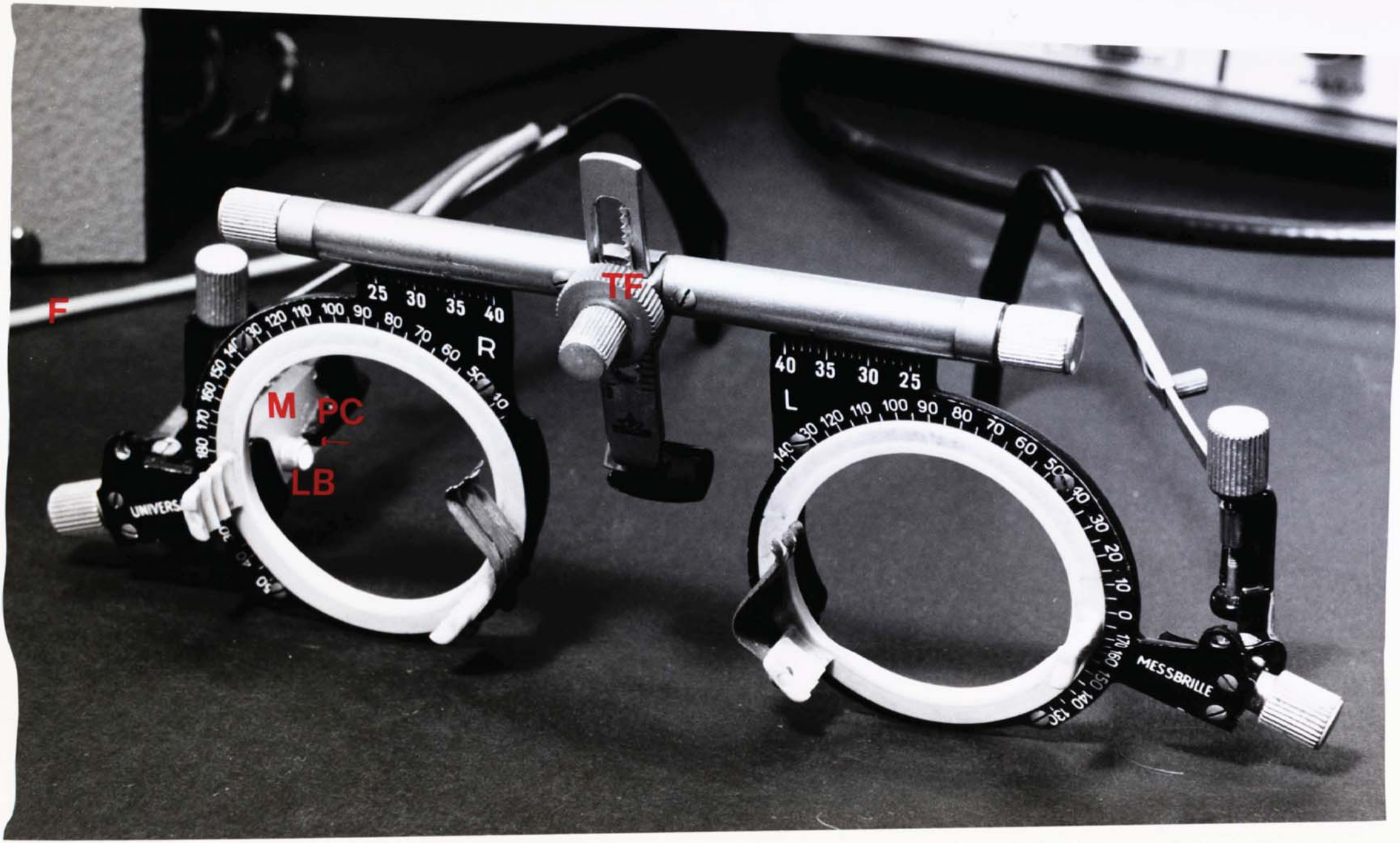

TR
P
C
B
TANDBERG
INSTRUMENTATION RECORDER SERIES 100
VOICE CHANNEL
FLUTTER COMP.
TAPE SPEED
TAPE MOTION
INPUT RANGE
INPUT OFFSET
OUTPUT
1
2
3
4

FIGURE 22: Enlarged view of the blink monitoring apparatus.

Key:

F	electrical flex to blink monitoring equipment control box.
LB	miniature tungsten filament light bulb in metal sleeve.
M	clip mounting (high-density polythene) attached to side arm of trial frame, bearing local light source and photocell.
PC	miniature photocell (entrance window nearest light source, as indicated ⟵).
TF	adjustable optometric trial frame ('Oculus' model).

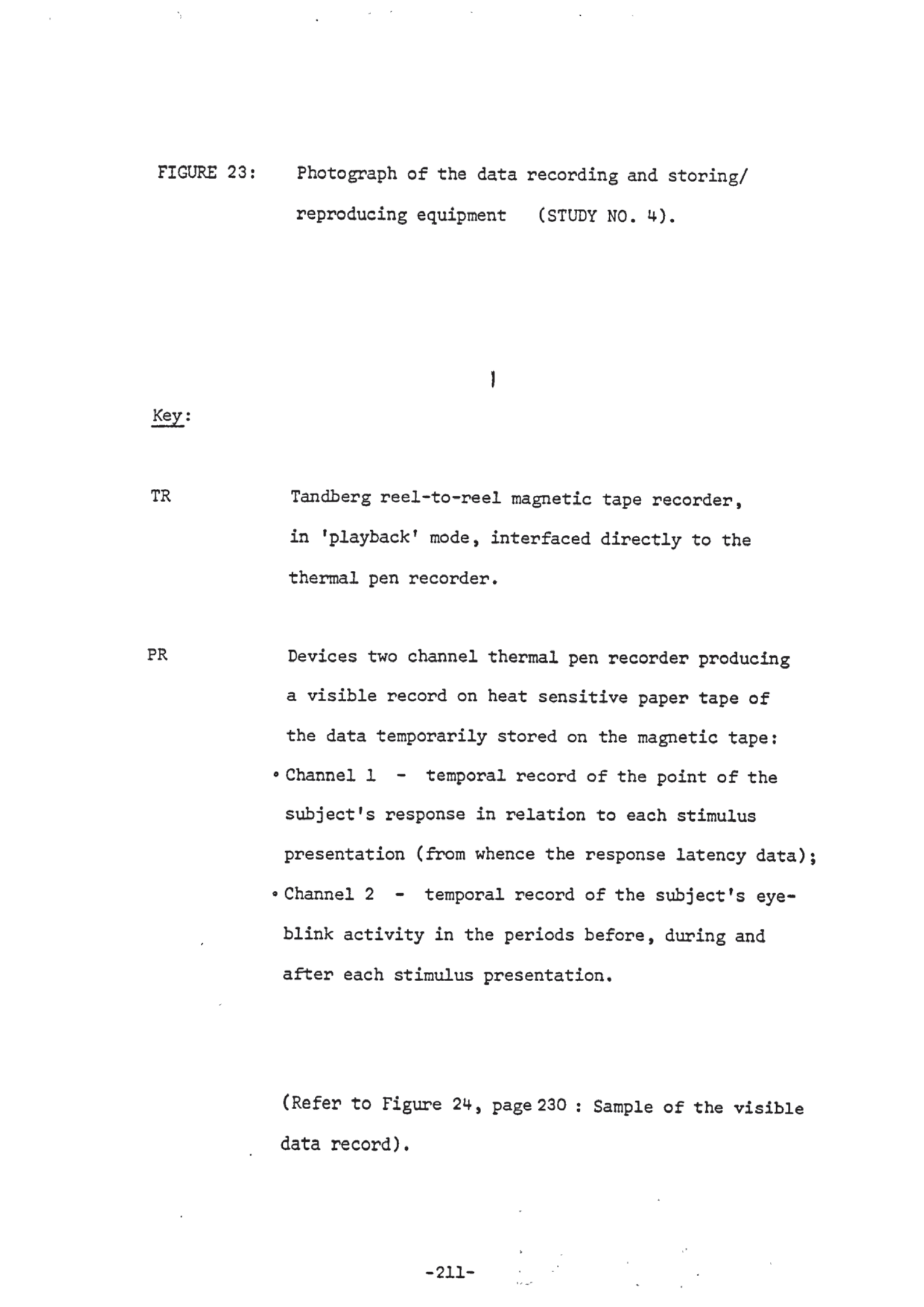

F
TF
M
PC
LB
R
L
MESSBRILLE

while they were engrossed in responding to the stimuli they were completely unaware of the spot of light in the far periphery of their field of view. It should be noted that the subjects were not told of the purpose of the small piece of apparatus clipped to the trial frame and, whilst it is a possibility that some may have guessed that it was recording their eyelid movements, they were not provided with any evidence from the equipment or the investigator of the correctness of their suppositions.

The blink monitor was mounted on the arm of the trial frame, a centimetre or so posterior to the back plane of the frame. The spot of light was aimed at the conjunctiva in the area of the temporal canthus and finely adjusted over the course of a trial run such that its position and brightness registered one blink unit every time that the subject blinked : in this position, because of the close proximity of the upper and lower eyelids, this was a comparatively easy adjustment because any blink, whether full or partial, resulted in the closure of the two lids. The brightness could be finely adjusted so that facial contortions or tics did not trigger the photocell. The blink monitoring appratus itself was silent, but a digital counter (which could be zeroed) served to indicate to the investigator alone that the device was working correctly during the adjustment and recording phases.

Since the data was to be stored on magnetic tape it would subsequently be necessary to prepare a visible record of the response latency and blink activity to facilitate analysis. Conveniently, this could be produced at a time when no data collection visits were scheduled merely by transferring the information on the magnetic tape (with the

FIGURE 23: Photograph of the data recording and storing/ reproducing equipment (STUDY NO. 4).



Key:

TR — Tandberg reel-to-reel magnetic tape recorder, in 'playback' mode, interfaced directly to the thermal pen recorder.

PR — Devices two channel thermal pen recorder producing a visible record on heat sensitive paper tape of the data temporarily stored on the magnetic tape:

- Channel 1 - temporal record of the point of the subject's response in relation to each stimulus presentation (from whence the response latency data);
- Channel 2 - temporal record of the subject's eye-blink activity in the periods before, during and after each stimulus presentation.

(Refer to Figure 24, page 230 : Sample of the visible data record).


TR
VOICE CHANNEL
FLUTTER COMP
TAPE SPEED
TANDBERG
INSTRUMENTATION RECORDER SERIES 100
1
2
3
4
INPUT RANGE
PR
Devices
1
2

recorder in the 'playback' mode) to paper tape via the thermal pen recorder (Figure 23, page 211). The calibrated time-base on the paper tape would permit the ready quantification of the information contained in the recording; collation and analysis of the data would then be the next logical procedure. A brief descriptive note on the several pieces of equipment used in this fourth study is provided in Appendix IX (pages 466- 468).

From those persons responding to the new advertising posters (Appendix X : Figure 31, page 470) twenty-seven individuals were finally selected for participation in the study. The group comprised 18 males, mean age 22.19 $\pm$ 2.48 years; 9 females, mean age 21.34 $\pm$ 2.48 years : group, mean age 21.91 $\pm$ 2.46 years. The acceptance profile adhered to in the selection of suitable persons for this study is appended (Appendix XIID, pages 498 - 499), and Table 16 (pages 213-215) summarizes the pertinent details of the group. This group of subjects provided a total of fifty eyes (34 male, 16 female), all of which achieved a subjective visual acuity of $^{6}/_{4}$ on the Landolt broken ring test chart at 6m in the test room when the best spectacle lens correction was placed in the usual plane before them. When the same group of eyes wore the optimum soft contact lenses which they had previously been fitted with, 76% (thirty-eight eyes : 25 male, 13 female) retained the subjective ability to read $^{6}/_{4}$ Landolt as easily and crisply as with their spectacle lens correction : the remaining 24% (twelve eyes : 9 male, 3 female) reported difficulty achieving constant $^{6}/_{4}$ vision, the spectacle lenses providing a more satisfactory and stable visual result.

Table 16: STUDY NO. 4 - Details of the Subject Group.

SUBJECT			KERATOMETRY	REFRACTION		SOFT LENS[b]			MONOC LANDOLT VA[c]
No.	Sex	Age (Years)	K_H : K_V	R_L-Spectacle R_x	Ocular[a]	BCOR	Ø	D	
1	M	19.92	7.850 X 10 : 7.600 X 100	-7.25, -0.75 X 180	-6.67, -0.63 X 180	9.00	14.5	7.00	6/4
			7.875 X 5 : 7.675 X 95	-7.50, -0.75 X 180	-6.88, -0.63 X 180	9.00	14.5	7.50	4 *
2	M	19.92	7.725 X 15 : 7.600 X 105	-5.00, -0.50 X 5	-4.72, -0.44 X 5	9.00	14.0	4.00	4 *
			7.700 X 160 : 7.587 X 70	-5.25	-4.94	9.00	14.0	5.00	4
3	F	22.08	7.725 X 177½ : 7.525 X 87½	-6.25, -0.50 X 170	-5.81, -0.43 X 170	8.70	14.0	5.75	4 *
			7.625 X 155 : 7.537 X 65	-6.50	-6.03	9.00	14.0	5.50	4
4	F	23.75	7.812 X 172½ : 7.862 X 82½	-1.25, -0.75 X 95	-1.23, -0.72 X 95	9.00	14.0	2.00	4 *
			7.675 X 155 : 7.725 X 65	-2.00, -0.75 X 85	-1.95, -0.71 X 85	9.00	14.0	2.25	4
5	M	25.92	8.350 X 30 : 8.225 X 120	-3.75, -0.25 X 15	-3.59, -0.23 X 15	9.30	14.5	3.50	4 *
			8.250 X 140 : 8.325 X 50	-4.25	-4.04	9.30	14.5	3.50	4
6	M	24.33	8.025 X 7½ : 7.887 X 97½	-2.25	-2.19	9.00	14.0	2.25	4
			7.987 X 165 : 7.800 X 75	-2.75, -0.50 X 180	-2.66, -0.47 X 180	9.00	14.5	3.25	4 *
7	M	26.58	8.137 X 12½ : 7.925 X 102½	-3.00, -0.50 X 5	-2.90, -0.46 X 5	9.00	14.0	3.25	4 *
			8.200 X 167½ : 8.050 X 77½	-3.75	-3.59	9.00	14.5	3.50	4
8	F	19.67	-						
			7.537 X 5 : 7.362 X 95	-5.00, -0.25 X 40	-4.72, -0.22 X 40	8.70	14.5	5.25	4 *
9	M	20.08	7.950 X 10 : 7.825 X 100	-3.75	-3.59	8.70	14.5	4.50	4
			8.000 X 170 : 7.825 X 80	-3.75	-3.59	9.00	14.5	4.00	4 *
10	M	24.25	7.250 X 32½ : 7.325 X 122½	-5.50, -0.50 X 90	-5.16, -0.44 X 90	8.40	14.0	5.00	4 *
			7.400 X 20 : 7.325 X 110	-4.75, -0.25 X 60	-4.49, -0.23 X 60	8.40	14.0	4.75	4 *

Continued/....

Table 16 : Continued

11	M	23.08	7.762 X 22½	: 7.712 X 112½	-3.00, -0.50 X 90	-2.90, -0.46 X 90	8.70 : 14.5 - 3.25	4
			7.775 X 157½	: 7.812 X 67½	-1.50, -0.50 X 90	-1.47, - 0.48 X 90	8.70 : 14.5 - 1.50	4 *
12	M	25.00	8.025 X 15	: 7.900 X 105	-6.25	-5.81	9.00 : 14.5 - 5.50	4
13	M	18.92	8.100 X 2½	: 7.925 X 92½	-4.25	-4.04	9.00 : 14.0 - 3.75	4
			8.062 X 177½	: 7.900 X 87½	-4.00	-3.82	9.00 : 14.0 - 3.50	4
14	F	26.42	7.875 X 172½	: 7.750 X 82½	-1.75	-1.71	9.00 : 14.0 - 2.00	4
			7.887 X 12½	: 7.787 X 102½	-1.50	-1.47	9.00 : 14.5 - 2.00	4
15	M	23.17	7.400 X 160	: 7.450 X 70	-3.00	-2.90	8.40 : 14.0 - 3.00	4
			7.362 X 177½	: 7.325 X 87½	-2.75	-2.66	8.40 : 14.0 - 2.75	4
16	F	20.50	7.700 X 165	: 7.800 X 75	-1.25, -0.50 X 85	-1.23, -0.48 X 85	8.70 : 14.0 - 1.75	4
			7.750 X 15	: 7.775 X 105	-1.50, -0.25 X 70	-1.47, -0.24 X 70	8.70 : 14.5 - 2.25	4
17	M	19.42	7.562 X 2½	: 7.425 X 92½	-2.25	-2.19	8.70 : 14.0 - 2.50	4
			7.637 X 177½	: 7.450 X 87½	-2.75, -0.25 X 25	-2.66, -0.24 X 25	8.70 : 14.5 - 3.00	4
18	M	20.17	7.962 X 22½	: 7.825 X 112½	-6.75, -0.75 X 95	-6.24, -0.64 X 95	9.00 : 14.0 - 7.25	4
			8.025 X 180	: 7.825 X 90	-5.75	-5.38	9.00 : 14.0 - 5.50	4
19	F	19.58	7.550 X 5	: 7.312 X 95	-4.75	-4.49	8.70 : 14.0 - 4.25	4
			7.562 X 5	: 7.350 X 95	-6.50	-6.03	8.70 : 14.0 - 6.25	4
20	F	20.00	7.962 X 167½	: 7.700 X 77½	-2.00	-1.95	9.00 : 14.0 - 2.00	4
			7.800 X 40	: 7.712 X 130	-1.25	-1.23	9.00 : 14.5 - 1.25	4
21	F	18.42	7.962 X 165	: 7.862 X 75	-2.50	-2.43	8.70 : 14.5 - 2.50	4
			7.950 X 12½	: 7.875 X 102½	-2.50	-2.43	8.70 : 14.5 - 2.50	4

Continued/....

Table 16 : Continued

22	M	22.75	7.625 X 177½	: 7.350 X 87½	-2.00, -0.25 X 135	-1.95, -0.24 X 135	8.40 : 14.0 - 1.25	4
			-					
23	M	24.25	7.975 X 5	: 7.825 X 95	-5.50, -0.50 X 150	-5.16, -0.44 X 150	9.00 : 14.5 - 5.25	4
			8.025 X 175	: 7.787 X 85	-5.75	-5.38	8.70 : 14.0 - 5.25	4
24	F	21.67	-					
			7.450 X 175	: 7.350 X 85	-2.00, -0.25 X 45	-1.95, -0.24 X 45	8.70 : 14.0 - 2.00	4
25	M	21.08	8.200 X 5	: 8.075 X 95	-2.75	-2.66	9.00 : 14.5 - 2.25	4
			8.225 X 20	: 8.000 X 110	-3.00, -0.50 X 40	-2.90, -0.46 X 40	9.00 : 14.5 - 3.25	
26	M	19.17	8.300 X 40	: 8.250 X 130	-5.00, -0.50 X 95	-4.72, -0.44 X 95	9.00 : 14.5 - 5.00	4
			8.312 X 165	: 8.262 X 75	-5.00, -0.50 X 90	-4.72, -0.44 X 90	9.00 : 14.5 - 5.00	4
27	M	21.42	7.575 X 165	: 7.450 X 75	-4.75, -1.00 X 110	-4.49, -0.89 X 110	8.40 : 14.0 - 4.75	4
			7.575 X 25	: 7.425 X 115	-6.00, -1.00 X 60	-5.60, -0.86 X 60	8.40 : 14.0 - 5.75	4

a Calculated assuming a Back Vertex Distance = 12 mm.

b Standard thickness daily wear soft hydrophilic (hydrogel: pHEMA) contact lens manufactured by Hydron Europe Limited.

c Level attainable with spectacle lens or soft contact lens refractive correction except: -

* visual acuity (VA) level unstable with soft contact lens, but entirely satisfactory with spectacle lens.

8.1B Description of Experimental Method

Aside from an initial screening visit, and subsequent attendances for an optometric examination and also soft contact lens fitting and checks, each subject made seven data collection visits. The first visit was a control visit, the subject wearing his best spectacle correction in the trial frame in the manner previously described in Section 6.1A (page 146). The remaining six visits were undertaken with the subject wearing his daily wear soft contact lenses. The first of these visits was on day number 1 of the lens wearing schedule, the session commencing after sixty to seventy-five minutes of lens wear : the second and third visits were at the same time on days number 3 and 5 of the schedule. The remaining three visits occurred in each of the three successive weeks, viz, days number 10, 17 and 24 (with, on these three occasions only, one day's latitude either side of the stated day in the schedule, by prior arrangement). However, these six appointments were at the same time of day as the first visit, and the duration of each of the seven visits was in the region of one hour.

At all visits the revised operating procedure incorporating a 15 degree eye movement prior to the presentation of each stimulus (as described in Section 6.3A, pages 152 - 153) was used. Following the rather negative results of the third validation study (reported and discussed in Section 7.3, pages 177 - 183) it was decided, somewhat arbitrarily, that when the right eye of the subject was being used fixation point number 6 (refer to Figure 15, page 126) would be viewed, and when the left eye was being tested the symmetrically-placed fixation point number 4 would be viewed. Thus, irrespective of the

eye under investigation, when the cue sounded the 'active' path of the visual axis would be up and towards the mid-line to view the mirror aperture 2.5m distant, in readiness for the presentation of the broken ring stimulus. When a response had been made, a 'relaxation' movement of the visual axis down and away from the mid-line would take place, to restore steady fixation to the spot some 15 degrees away from the point which had just been viewed on the mirror. The control settings were maintained at setting 2 (2.9s : Table 5, page 105) for the stimulus presentation and at setting 3 (2.65s) for the interval. All stimuli were presented at negative contrast, and at setting 3 (- 35.62% : Table 4, page 99). The delay time on the auditory cue device was maintained at 1.50s.

At the first (spectacle lens) visit, the best spectacle prescription was centred before the right eye, the left being occluded. (In the majority of cases, both eyes of a subject were used to generate data; the order of investigation was always right eye then left eye). The TV system was switched on, the control settings were checked (Appendix XIIID, page 504) and the pre-recorded instructions were delivered (Appendix XIVC, pages 509 - 510). The Landolt acuity was re-checked and then several trial runs were undertaken, giving the subject experience of operation with the TV system before formal data collection commenced, and also providing an opportunity for the investigator to adjust the alignment of the blink monitoring apparatus for maximum precision of recorded data. When both parties were satisfied with the arrangements, a sequence of three‡ monocular runs

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‡ As a result of the second validation study (discussed in Section 7.2, pages 174,176) three runs had been established as providing a satisfactorily accurate basis for data generation.

(comprising one hundred stimuli each) were undertaken under constant conditions; as a rule, this took in the region of twenty to twenty-five minutes. As in the previous studies, subjects were advised that requests for rests would be permitted between runs; however, almost without exception, subjects seemed to prefer to undertake the three runs virtually one after another (with only a brief pause to permit a check to be made of the alignment of the blink monitoring apparatus, for example), deferring the rest period to the interval time between the separate investigations on the two eyes. On completion of data collection on the second (left) eye, the subject was discharged until the following week, when soft contact lens wear would commence.

During the course of each run, the investigator could keep a check on the blink and response latency data being silently recorded on the several tracks of the magnetic tape simply by watching the oscillations of the indicator beams on the CRT monitor mounted on the control panel on the front of the recorder. New reels of professional studio quality sound recording tape were used in this study. Each new reel of magnetic tape, prior to its use as the medium for data recording, was run through the tape recorder twice in the 'fast-forward' mode. This was a slightly pedantic precaution, but previous experience with new reels of tape when hi-fi recording had demonstrated that this minimized the problem sometimes encountered of new reels of tape stretching or sticking. Nowadays, this problem has been greatly reduced by the use of a polyester base to the magnetic film, but nevertheless this procedure always seems to improve the smooth running and take-up of tape on the spool. In the present work, tape stretching would produce local and unpredictable variations in the time-base of the recording, clearly an unwanted

source of error. To further ensure accuracy, recording on the tapes was started about 8m (approximately 25 feet) in from the commencement of the magnetic film : this precaution would reduce the possibility of tape slipage around the capstan of the take-up spool and promote an even speed of tape traverse across the recording head. Each spool carried 555m (1800 feet) of magnetic tape. This tape passed across the recording head at a constant $4.75 cms^{-1}$ ($1\frac{7}{8}$ inches per second), thus giving in excess of three hours recording time per spool, i.e., a new reel of clean tape was required to be put on the recorder after every three subjects (i.e., six eyes), a fairly economical and convenient means of recording data. Before the commencement of every run the footage on the recorder's tape counter was noted next to the tape reel number on the TV manual recording chart, enabling the recorded data to be matched readily against the subjective responses for analysis at a future date.

One week after the control visit, the regular daily wear of soft contact lenses was to commence. An experimental procedure similar to that described above was followed at these six visits, with the exception that the subject attended having worn his soft contact lenses for at least one hour. As stated, the first of these visits was exactly one week after the spectacle lens visit, on day number 1 of regular daily lens wear, commencing at a point sixty to seventy-five minutes after lens insertion. Precautions were taken to ensure that the soft lenses were not inspected, inadvertently damaged or otherwise interfered with by the subject prior to the start of the experiment. These procedures are described more fully in Section 8.2 (vide infra, pages 222 - 226), but briefly, on receipt of the lenses from the manufacturer, certain of their parameters were checked and the subject attended for a wearing trial and

teaching session. Provided all was satisfactory, the lenses were then chemically disinfected and stored in soaking solution in their coded sealed glass vials in the research clinic. Then, on the scheduled first day of lens wear, the subject attended about one and a half hours before the regular time of his appointment and the lenses were given over to him to insert as per the advice given at the previous practice session. He was then temporarily discharged, with the reminder that he should return in approximately one hour for his first data collection visit wearing soft lenses.

When the subject attended for his appointment, the fit of each lens was checked, the degree of comfort ascertained and the monocular visual acuity assessed on the Landolt chart at 6m. Then both soft lenses were removed in turn and rinsed with the proprietary soaking solution : the right lens was then re-inserted, and the left lens was immersed in a clean stoppered vial half-filled with fresh soaking solution. Because any stimulus to blink normally results in a bilateral eyelid movement, in this work specifically designed to investigate blink activity any extraneous stimulus to blink should be avoided. Thus it was felt to be a desirable point of experimental design to remove the left lens while monocular investigation of the right eye was being undertaken, and vice versa (cf., the conditions of soft lens wear in the third validation study, reported in Section 6.3B, pages 155 - 160). Further to this, however, because the soft lens which was removed from the eye would have to be temporarily stored in solution, it became necessary to rinse the other lens as well, in order to confer any possible benefits of the procedure (for example, the rinsing off of any tear debris) upon both lenses. When this procedure had been completed, the left eye was occluded,

and the fit of the right soft lens and the Landolt acuity level were both quickly re-checked. The TV system had been switched on and its control settings checked previously, so now the pre-recorded instructions (as at the first spectacle lens session : Appendix XIVC, page 509 -510) were delivered*. Trial runs were permitted, during which the blink monitoring apparatus was adjusted. The three monocular runs were then undertaken under similar conditions to the first visit, with only brief rests between each run. On completion, the subject was handed the questionnaire sheet (Appendix X : Figure 33, page 472) and was requested to give his subjective evaluation of three aspects of soft contact lens wear (an assessment of the stability and quality of the visual correction and the comfort of the lens), indicating his single choice from the five statements provided under each heading by placing a tick in the adjacent box : space for further comments was provided at the foot of the sheet. The trial frame with occluder was then taken from the subject's face, the left lens was inserted and the right lens removed, rinsed and placed in another clean stoppered vial of soaking solution. The procedure of re-checking, trial runs and data generation was then repeated with the left eye.

On completion of data collection, the subject was requested to indicate

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* It should be noted that the pre-recorded instructions were only delivered to the subjects at the first two of the seven visits : at subsequent visits the tape was only played if the subject, in response to an enquiry, indicated that he required to hear it. However, trial runs were always undertaken to ensure that the subject was entirely familiar with the operating technique.

his impressions on the remaining left hand side of the questionnaire. Then the trial frame was removed and the right soft lens was re-inserted. Finally, any queries in connection with soft lens wear or care were answered.

The partial refund of the original fee (up to £30, at the discretion of the investigator, based upon the subject's record of attendance over the course of the study) was made to each subject prior to his departure on completion of the final soft contact lens visit.

8.2 A Note on Aspects of Soft Contact Lens Wear in Relation to this Study

Certain further points, relating specifically to soft contact lens wear, should be noted in the context of this work (vide also Appendix XI : Figure 46, pages 490 - 492). The first is that, as a consequence of the generous provision of supplies of solutions by the contact lens manufacturer, a chemical rather than heat disinfection regime was instituted to maintain lens hygiene. Two solutions were issued to subjects, along with verbal and printed instructions on their use. One was to help prevent mucous and protein deposition upon the lens surface, being an isotonic buffered solution with a surfactant cleaning agent, for daily use upon removal of lenses. The other was a multi-purpose disinfectant rinse and storage solution, being an isotonic buffered bactericidal soaking solution, for use at any time to clean and rinse the lenses and also to serve as the preferred lens storage medium.

Both solutions contained as preservatives Thimerosal 0.0025%, EDTA 0.1%, and Chlorohexidine Gluconate 0.0025%. The relatively low

concentration of the latter bactericidal agent is to be noted (fifty per cent of the concentration as found in similar solutions as produced by other major soft contact lens manufacturers); this is a significant feature in connection with the sensitization of ocular tissues. In addition, unpublished data on file at Hydron Europe Ltd., besides indicating the microbiological efficacy and minimal toxicity of these solutions, has demonstrated that their use does not significantly alter soft contact lens geometry (Walker 1981).

Finally, in connection with the solutions, it should be noted that during the data collection runs, when one lens was temporarily removed from the subject's eye, it was rinsed and stored in a clean glass vial containing this same proprietary soaking solution.

The soft contact lenses were fitted within the constraints of the established routine, as used in the third validation study and outlined in Appendix XI : Figure 46, pages 490 - 492 . The standard thickness lathe cut soft contact lenses were then ordered direct from the manufacturer on the basis of the specification of two dimensional parameters (viz, overall external diameter and back central optic radius) and the refractive power required. The lenses were received in solution in sealed glass vials, with the three parameters printed on the plastic cap covering the crimped aluminium seal. Prior to dispatch from Hydron Europe Ltd. all the lenses, in addition to the usual quality control checks undertaken during and after manufacture, underwent a further inspection check to guarantee correspondence of actual and cap values for the three specific parameters. On receipt of each lens, the cap seal was broken and the lens removed; its back vertex power was then quickly checked on a focimeter. The lens was

next rinsed with fresh soaking solution, excess liquid shaken off, and then carefully mounted on a transparent stage on an optical projection apparatus. From the image cast on the matt white viewing screen of the latter it was thereby possible to assess the optical and surface quality of the lens : any imperfections arising as a result of poor lathing or polishing, or other damage, showed up as dark lines or shadows upon the projected image. Provided that all appeared satisfactory, the lens was rinsed and then re-sealed in its storage vial containing fresh soaking solution. The cap was marked with a subject identification code (initials, plus 'R' right or 'L' left) and the vial was put in a rack in the research clinic.

When both lenses for an individual subject had been received and checked, the subject was informed that he should attend for a wearing trial and teaching session. At this visit, the lenses were worn for twenty minutes and then, for each eye in turn, the fit and the Landolt visual acuity was checked, both per se and also against the details on the original lens fitting sheet. Provided all details tallied, and that fit, acuity and comfort with the lenses was suitable for the proposed study and, of course, acceptable to the subject then he proceeded to a session of instruction on all aspects of soft lens handling and hygiene. He was given the patient information booklet published by Hydron Europe Ltd., along with a sheet of additional notes (reproduced in Appendix XI : Figure 45, page 489) to reinforce the verbal instructions. The rôles of the two solutions were described in the context of soft lens handling, and the subject was then allowed to practice lens insertion and removal until he was judged proficient by the investigator and indeed felt confident in the procedures himself.

On completion of this session, again provided that all appeared satisfactory from the viewpoint of both parties (i.e., subject and investigator), the experimental schedule was consulted and the sequence of seven data collection visits was agreed. The subject then paid the full fee, it being stated again that prompt and reliable attendance for all vists would entitle him to a fifty per cent refund, payable on completion of data collection at the seventh visit. The lenses were then removed, rinsed and checked with the aid of a hand lens (magnification X8) against a light source to ensure that the lens edges especially had not been damaged during handling. After a further rinse, the lenses were sealed in their storage vials to await the start of the experiment. Before he departed, the corneae of the subject were checked with vital stains (one drop 2.0% W/V Fluorescein Sodium B.P. and one drop 1.0% W/V Rose Bengal) on the slit lamp biomicroscope, under both white and ultra-violet light. Finally, his own spectacles were returned to him, and he was given an appointment card (reproduced in Appendix X : Figure 32, page 471) listing details of all his visits and also providing emergency telephone numbers for use in the event of the occurrence of any problems during the course of the study.

Of importance with regard to this experimental study, both of itself and also as a point of good clinical practice, the corneae of each subject were regularly checked during the first month of lens wear. Regular daily wear of a soft contact lens, even when the latter has been fitted by an investigator using an established and regular procedure, poses a potential problem being a possible source of embarrassment to normal corneal metabolism (vide Sections 1.3Diii and 1.3Dv, pages 19 and 22 - 23 , respectively). Hence regular

and systematic monitoring of the corneal tissues was indicated. These checks took place on completion of data collection and before the subject departed, at the second soft lens visit (i.e., on the third day of lens wear) and at weekly intervals thereafter. Inspection was by naked eye and slit lamp biomicroscope. Because of the absorptive properties of soft lenses, vital stains were used only at the last visit (i.e., after one month of regular daily lens wear); the eyes were irrigated with fresh normal saline to remove excess stain, and the subject was firmly instructed not to insert his lenses until the following day. The subject had bought twelve months aftercare as part of his package : thus, on completion of the study, he was advised to return for three further check-ups, in three, six and twelve months time, or earlier if any problems arose. He was also advised to find a regular supplier of the two Hydron Europe solutions before either of the initial bottles was empty, to ensure continuity of lens wear and care.

CHAPTER 9

EXPERIMENTAL DATA (II): AN INVESTIGATION INCORPORATING THE TV SYSTEM

CHAPTER 9

EXPERIMENTAL DATA (II):
AN INVESTIGATION INCORPORATING THE TV SYSTEM

9.1 STUDY No. 4 : To Investigate the Possible Adoption, by Persons Adapting to Soft Contact Lens Wear, of a Strategy to Optimize their Visual Performance

(Refer also to Section 5.3 and Chapter 8, commencing pages 133 and 203 , respectively)

9.1A The Experimental Data and Statistical Analyses

In addition to the correctness of subjective response data (manually recorded, as in the three validation studies) this fourth study had generated data relating to the latency of subjective response and also to the blink activity associated with each of the one hundred stimuli comprising every run with the TV system. The protracted period of time then required to be spent upon the collating of all this information for subsequent statistical analysis should be remarked upon here. This was occasioned partly by the sheer volume of data collected over the study, and partly by the prolix manner in which the results had to be prepared.

Each subject's correctness of response data was manually scored by the investigator upon the recording charts (Appendix V : Figure 27, page 427) over the course of each run with the TV system. This raw data was corrected for guessing (Appendix V, pages 426 - 430) and then, for each of the ten stimuli in the repeating presentation cycle in

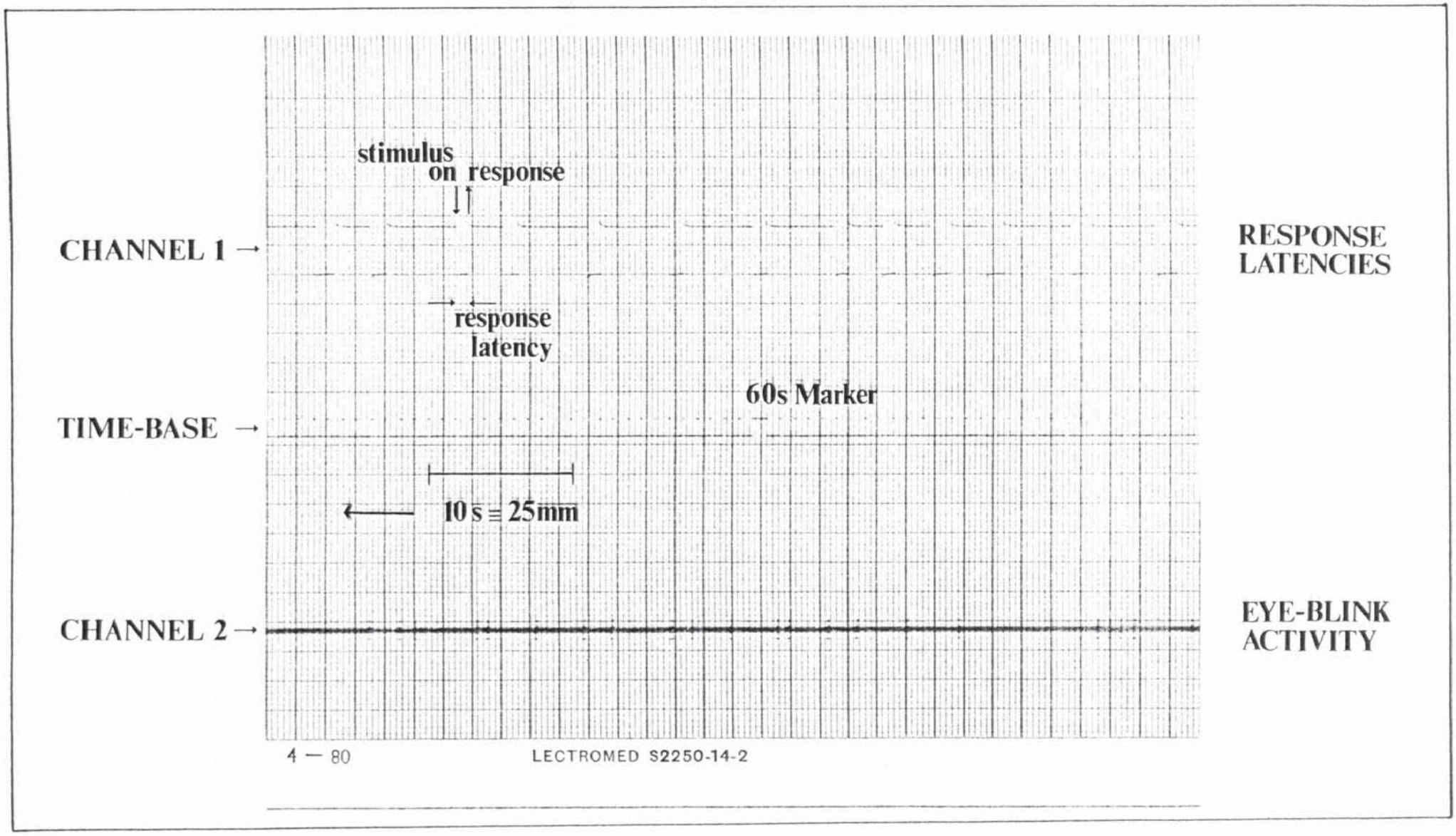
turn, the mean result (over the three runs) was entered into the appropriate space on the summary sheet (Appendix X : Figure 36, page 475). Full results for the study are given in Appendix IV : Table 32, pages 315 - 328.

The additional data unique to this final study was recorded in the first instance (essentially for reasons of convenience and reliability, as discussed in Section 8.1A, page 205) upon magnetic tape. Subsequently, in the evening or free period following the sequence of subject attendances during the day, it was necessary to transfer these data from the magnetic tape store to a visible record on paper tape. This was achieved by interfacing the magnetic tape recorder to a thermal pen recorder and, with the heat sensitive paper advancing at a constant chosen speed ($2.5 mms^{-1}$), replaying the appropriate reels of magnetic tape. Accurate zeroing of the magnetic tape recorder's tape footage counter at the commencement of replay of each numbered tape reel ensured that the data, once printed, could be matched readily to the corresponding set of manually recorded correctness of subjective response data. In addition, each printed record was marked prominently with the subject's name, the visit number, right or left eye and the run number.

The blink activity and response latency data, once printed out as a visible trace on a calibrated strip of recording paper (Figure 24, page 230) had to be quantified to facilitate subsequent analysis. The heat sensitive paper advanced at a constant (nominal) speed under the thermal pens. This assumption of constancy was always checked at certain points over the entire course of the printing

FIGURE 24: STUDY No. 4 - Sample of the visible data record produced on the heat sensitive paper tape

FIG. 24


stimulus on response
CHANNEL 1 →
response latency
60s Marker
TIME-BASE →
10 s ≡ 25mm
CHANNEL 2 →
RESPONSE LATENCIES
EYE-BLINK ACTIVITY
4 — 80
LECTROMED S2250-14-2

procedure and largely substantiated[+]. From a knowledge of the paper speed (nominally 2.5mms^{-1}) the scale graduations over-printed on the recording paper were readily calibrated (nominal scale : 1.00mm represented 0.40s) : thus the duration or, alternatively, the occurrence in time (relative to the start of the particular run, for example) of recorded events could be accurately quantified.

This proved to be a fairly straight-forward but time consuming procedure. Each run, largely regardless of subject or visit number, produced a strip of paper bearing details of response latency and blink activity of just over one metre in length. At each of the seven visits there were three runs, and data was collected from fifty eyes. The total length of paper tape produced by this study was thus, by calculation, in excess of one kilometre! Clearly, quantification of all of this volume of data was not a practical proposition within the time-scale of the project. Consequently, the possibility of a data sampling procedure was investigated, whereby only a certain constant but hopefully representative proportion of the data for each individual run would be quantified. It was demonstrated (Appendix IV : Table 38C, pages 417-425) that twenty sampling positions, at fixed points in each run of one

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+ Three checks upon the time-base printed along the bottom edge of the thermal paper strip were made for each printed run, with the aid of a calibrated (mm) transparent ruler : the location of these checks were near the beginning, in the middle and approaching the end of the one hundred responses. If any variation was found then, for that particular run, the scale value used to convert the linear measurement into a temporal one could be altered and errors avoided.

hundred subjective responses (i.e., two samplings corresponding to the subjective response latency and blink activity associated with each of the ten stimuli) represented a statistically satisfactory approach to the summarizing of the data produced by the full experiment. Also, of course, checks were made over the entire course of the printing procedure upon both the constancy of tape reproduction (Appendix IV : Table 38B, pages 415 and 416) and upon the accuracy of the investigator in measuring the printed data traces (Appendix IV : Table 38A, pages 413 and 414). Fortunately, in neither of these respects was precision found to be lacking (vide Summary, page 412).

Consequently, for each printed run the twenty sampling positions were identified, and the response latency ('reaction time') and blink activity associated with each of these pre-determined positions was quantified and entered on the appropriate totalling sheets (vide copies of these sheets in Appendix X : Figures 34-35, pages 473 - 474). Response latency data (unit of measurement : s, seconds) was measured and recorded to an accuracy of one decimal place only, as a consequence of the limitations imposed by the available instrumentation. The mean result over the three runs for each eye at each visit was calculated and entered on a summary sheet (Appendix X : Figure 37 , page 476). Blink data was assessed over the three periods (before and during stimulus presentation, and after the subject's response) on the basis of the number

of events per time span‡, whence blink rate (i.e., number of blinks per second) could be determined for each period. Again, upon completion of quantification of this data for the three runs undertaken with each eye at each data collection visit, the mean results were calculated and entered on the summary sheet (Appendix X : Figure 38, page 477). Full results of response latency and blink data are listed in Appendix IV : Table 33, pages 329-338 ,and Table 34, pages 339 - 389 , respectively). Finally, a table of the collated results of the subjective choices in connection with the ranked scales provided on the questionnaire relating to certain aspects of soft contact lens wear is also given in Appendix IV : Table 36, pages 405 - 406.

The experimental data generated by this study could be placed in five separate divisions, designated thus : 'TV score', 'reaction time', blink rate at 'refixation', 'stimulus on' and 'stimulus off'.

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‡ The periods of time available before and after each stimulus presentation remained constant throughout the entire study by virtue of the incorporation of the auditory cue device in connection with the specific eye movement. The setting of a 1.50s time delay on the cue meant that the period after each subjective response (designated 'stimulus off') was always of 1.50s duration : when the cue sounded, the time available for the refixatory eye movement (designated 'refixation') was 2.65 (interval time : control setting 3) - 1.50, i.e., 1.15s. The subjective reaction time, of course, provided the third period (designated 'stimulus on').

When all the data generated by the study had been assembled, the primary intention was to assess whether any of the five factors were of greater statistical significance than others.

To facilitate comparison between the ten possible pairings of factor combinations (Table 17, page 235), a matrix was drawn up in computer memory files* of the data generated over the seven experimental sessions under the five headings (i.e., that data presented in Appendix IV : Tables 32-34, pages 315 - 389).

To assess possible statistical significance of the several factors, from pairwise comparisons, a program (Ref: JP VIS; Language FORTRAN

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* For convenience of availability, the equipment used to handle this data was the direct access computer housed in the Clinical Neurophysiology Unit, Department of Ophthalmic Optics, The University of Aston in Birmingham : Digital pdp (programmed data processor) Model 8/e. The data was typed into memory files using a keyboard attached to a DECScope visual display unit (which facilitated the continuous checking of correctness of data input), and all results were automatically printed out upon unburst perforated computer paper rolls using a DECWriter IV ink-head printer. All data programming, storage and handling was performed upon 200mm diameter magnetic 'floppy discs'. All of the computing equipment and accessories were manufactured by Digital Equipment Corporation, Galway, Ireland.

Table 17: STUDY NO. 4 - The Ten Possible Pairings Of Factor Combinations.

		TV SCORE	REACTION TIME	BLINK RATE: REFIX	BLINK RATE: ON	BLINK RATE: OFF
BLINK RATE	OFF	1	2	3	4	
	ON	5	6	7		
	REFIX	8	9			
REACTION TIME		10				
TV SCORE						

II : see Appendix VIC, pages 439 - 451) was devised to undertake linear regression/correlation analysis upon the appropriate data stored in the computer memory files for each of the ten factor-pairs in turn. It is to be noted that the assumption of linearity of relationship is the most important requirement to justify the use of the Pearson correlation coefficient as a measure of relationship between two variables (Runyon and Haber 1980 : vide Appendix VIIC, pages 457-458). It is not necessary that the coefficient be calculated only with normally distributed variables : so long as the distributions are unimodal and relatively symmetrical, a Pearson correlation coefficient may legitimately be calculated. Whilst the range of values of certain of the five variables in the present case was a little restricted, nevertheless scatter diagrams (produced in longhand fashion) of randomly selected sets of results indicated that, for several of the pairs of variables**, an approximately linear,

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** On the basis of the appearance of the scatter diagrams, three strong and two possible correlations apparently existed : between TV score and reaction time, blink rate when stimulus off and possibly at refixation, and also between reaction time and blink rate when stimulus off and again possibly at refixation. The failure to observe any apparent evidence of relationships amongst the results of the remaining five comparisons may be because they were, in fact, unrelated or that they were related in a non-linear fashion : the restricted range of values of certain of the factors was an unfortunate feature here, hindering the resolution of this point.

unimodal relationship could be observed. Thus the use of a linear-based statistical procedure was felt to be justified. Consequently, for the available data at each of the seven experimental visits, this program established, in the following sequence, the Pearson product-moment correlation coefficient (r) and the two constants (a and b) associated with the general equation ($Y = a + bX$) describing the best-fit linear regression line through the experimental results (method of least squares). The program permitted analysis to be undertaken upon the data of individual eyes but, more particularly, upon the massed data of several eyes under various groupings : viz, the whole group and male/female, Landolt visual acuity level (with spectacle or soft contact lenses), degree of ocular refraction, specific soft contact lens fit, and corneal/soft contact lens fit relation (Table 18, page 238). Certain of the results of this lengthy sum correlation analysis are presented in Appendix IV : Table 35, pages 390- 404.

With regard to the ranked subjective impressions of, specifically, stability and quality of soft contact lens vision it was considered that a statistically based comparison with possible objective indications of these two factors might prove of interest. Such objective measures might be obtained from a consideration of the best-fit linear regression line (as fitted by Program Ref: JP2, Appendix VIB, pages 435 - 438) through the appropriate correctness of subjective response results, comparing the subjective assessment of stability of soft lens vision with the obtained first standard error of estimate associated with the linear regression, and the subjective assessment of quality of soft lens vision with the

Table 18: STUDY NO. 4 - Sum correlations undertaken.

1.	SEX	Whole group eyes		N = 50 eyes
		Male eyes		34
		Female eyes		16
2.	LANDOLT VISUAL ACUITY (MONOCULAR)	$6/4_{(constant)}$ - spectacle lens:	$6/4_{(constant)}$ - soft contact lens	38
			$6/4_{(variable)}$ - soft contact lens	12
3.	OCULAR REFRACTION	Spherical	$\lessdot \bar{2}.99$ DS, $\geqslant \bar{3}.00$ DS $\lessdot \bar{5}.99$ DS, $\geqslant \bar{6}.00$ DS	11, 11, 2 : 24
		Spherico-cylindrical	$\lessdot \bar{0}.50$ DC, $\geqslant \bar{0}.51$ DC $\lessdot \bar{1}.00$ DC	19, 7 : 26
4.	SOFT CONTACT LENS FIT	B.C.O.R.	8.40 mm, 8.70 mm, 9.00 mm, 9.30 mm	
		vs		
		Ø	14.00 mm 14.50 mm	7, 7, 13 : 27
				8, 13, 2 : 23
5.	FIT RELATION	$\triangle$ (= B.C.O.R. - K_f)	0.70 mm > 0.89 mm, 0.90 mm > 1.09 mm, 1.10 mm > 1.30 mm	
		vs		
		Ø	14.00 mm / 14.50 mm	5, 12, 10 : 27
				9, 9, 5 : 23

actual gradient of the regression line***. The subjective choices tabulated in Appendix IV : Table 36, pages 405- 406 indicate that, for both of the criteria under consideration here, the chosen level of ranking was either '1' or '2', or very occasionally '3'; i.e., in no instance was either criteria regarded by the subjects as poor or unacceptable. Such skewed results suggested that the subjective choice decisions could possibly be reduced to a binary level without sacrificing accuracy of the data : viz, redefining subjective ranking as a dichotomous variable, where '0' now represented former rank level '1' on both criteria and '1' represented the slightly less than perfect but nevertheless acceptable responses formerly designated rank levels '2' and '3'. In this way the correlation between a binary variable (subjective ranking) and a variable for which the results could take any one of a number of different values (the appropriate objective results arising from linear regression analysis) could be established : this correlation coefficient is commonly referred to as the point biserial coefficient (Appendix VIID, page 459).

This procedure was undertaken upon the subjective choice data relating to the whole group of eyes (N=50); it was repeated upon the

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*** Such relationships were hypothesized by the use of the linear regression procedure (viz, program Ref: JP2, vide Section 7.4A, pages 183 - 184, and Appendices V and VIB), both to indicate the spread or variability of results about the regression line and also to quantify a threshold acuity level, when considering visual performance in terms of stability and quality of vision components.

data of the smaller group of eyes (N = 12) which could not achieve a constant Landolt acuity level with the optimum soft contact lens comparable with that level obtained when wearing the best spectacle correction. The largely non statistically significant results are presented in Appendix IV : Table 37, pages 407 - 410.

9.1B A Preliminary Discussion of Results

Whichever of the several sum correlations was considered, over the six data visits corresponding to the first month of soft contact lens wear there was revealed (Appendix IV : Table 35, pages 390-404) a consistently statistically significant correlation between the following three pairs of factors:

(i) TV score and response latency

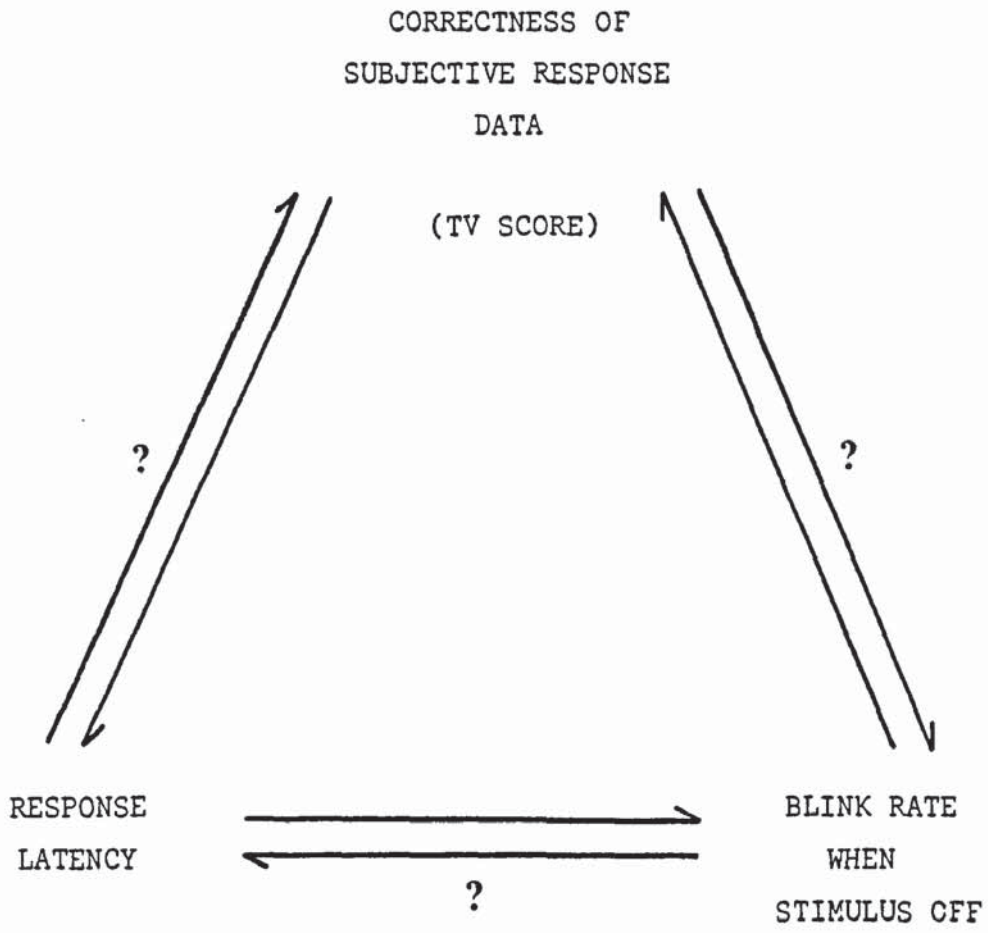
(ii) TV score and blink rate when stimulus off

(iii) Response latency and blink rate when stimulus off

Of these three pairs of variables, the correlation between TV score and response latency was consistently the most statistically significant ($p < 0.001$ or, less frequently, $p < 0.01$).

This finding suggested the possible existence of a triad of statistically significant factors (Figure 25, page 241). The consistency of their statistical significance, albeit at varying levels, under the differing circumstances purposely investigated by the sum correlations (Table 18, page 238), suggested further that these three factors were maintained in some degree of equilibrium by alterations in approach or subjective strategy with regard to the visual

FIGURE 25: STUDY NO. 4 - The triad of consistently statistically significant factors



location and identification task being undertaken.

The results of the analyses undertaken to establish point biserial coefficients (Appendix IV : Table 37, pages 407 - 410) in connection with the ranked subjective impressions of stability and quality of soft contact lens vision were largely not ($p > 0.1$) or occasionally only weakly ($p < 0.05/0.02$) statistically significant. These results were perhaps not surprising when one considers that an attempt was being made to discriminate between subjective replies that had indicated that the two aspects of vision were found to be quite acceptable (although to slightly differing degrees). A further point is to be noted in connection with the analysis of the data of the subgroup of eyes (N = 12), i.e., those eyes which registered a less than optimum (fluctuating) level of subjectively determined Landolt acuity : under neither visual criteria, viz, stability nor quality, was a statistically significant coefficient ($p > 0.1$) established. The contention that a subject is a poor judge or observer of his own performance might again be remarked upon (cf., Section 7.4Aii, page 187).

CHAPTER 10

GENERAL DISCUSSION AND CONCLUSIONS

CHAPTER 10

GENERAL DISCUSSION AND CONCLUSIONS

10.1 Introduction : Visual Performance

The concept embodied by the term 'visual performance' has already been discussed (Chapter 3, page 50 et seq.) in the context of the research project. It was appreciated that qualitative in addition to quantitative information would be required to establish such a measure. It was essential that certain key parameters, viz, the size of stimulus critical detail, the contrast and illumination level of stimulus and background, and the stimulus presentation time (Cobb and Moss 1928a, 1928b) were incorporated into the test procedure. It was also remarked that the rate as well as the duration of stimulus presentation should receive attention (Fry and Enoch 1959, Vasa 1960) : this statement accords with the views of Sarver (1972) in the context of soft contact lens wear.

In addition, decisions regarding the physical form and manner of presentation of the test stimulus had to be made. The intention was to develop a visual performance assessment procedure for use in a clinical environment : increased accuracy of measurement might be at the expense of applicability, so the actual manner of testing had to receive careful consideration.

10.2 The Research Project

The stated objective of the research effort reported herein was to

investigate the visual performance of a subject who was wearing a refractive correction in the form of a soft hydrophilic contact lens. To make for a concise project, the scope of the investigation was restricted intentionally to an assessment of visual performance aspects of the new soft contact lens wearer during the first month of regular daily lens use (vide Section 5.3, pages 139-140).

By reference to the appropriate literature, and within the constraints of the available time and financial budget imposed upon the work, a semi-automated investigative system, utilizing the presentation of broken ring test stimuli on a TV screen, was devised expressly to facilitate such an inquiry (Chapter 4, page 75 et seq.).

The research project itself comprised two distinct stages. The first phase was concerned with the optimization of the major variables associated with the operation of the investigative TV system (vide Section 5.2, pages 117 - 132 , and Chapters 6 and 7, pages 144 et seq. and 162 et seq., respectively). The second phase involved the utilization of the validated system in a unique investigation of visual performance aspects of soft contact lens wear (vide Section 5.3, pages 133 - 142, and Chapters 8 and 9, pages 203 et seq. and 228 et seq., respectively). The results of the two phases of the project will now receive further consideration.

10.2A Project Phase I : The TV System

Whilst results obtained with the existing TV system have been shown to be reliable and repeatable (vide Sections 7.2, pages 169 - 176, and 7.4Avi, pages 197 - 198), the equipment as it stands has several

shortcomings. These arise largely as a consequence of the flexibility of approach which was adopted at the design stage, with the intention of facilitating any alterations or adjustments to the range of control settings in the light of experience of operation. Ideally, when a workable and acceptable prototype system had been evolved, a completely new piece of apparatus would have been built, incorporating all the requisite features as a whole and utilizing the latest electronic component technology. However, this revision was not possible, and the work reported herein proceeded using the fully serviced prototype system.

If a similar system (or a revised version of the original system) had been built today, it would ideally have incorporated design features reflecting the recent rapid advances in micro-electronics technology. The ready availability and comparative low cost of personal mini-computers and requisite peripheral hardware (such as visual display units and on-line thermal printers) demonstrates the feasibility of approach and advantages offered by the new technology associated with the silicon chip.

For possible routine use in a clinical environment, the efficiency of such a piece of equipment would be enhanced by complete automation. In conjunction with automated randomized stimulus presentation on the screen of the visual display unit (VDU), it would be feasible to continuously record the parallel information relating to orientation and correctness of subjective responses over a run. Then, on command, at the completion of data collection a built-in packaged statistical program could undertake a linear regression analysis, for example, upon the 'corrected' results, in the manner previously described in

Section 7.4B, (pages 200 - 201) and Appendix V (pages 426-430).

Automation and computerization are currently rapidly developing spheres within optometric practice, not only in connection with the dispatching of certain hitherto mundane or repetitive aspects of practice management but also (as discussed in Section 4.1, pages 75 - 77) within the clinical environment of the consulting room itself. Furthermore, TV displays are reported subjectively to be very well tolerated (Arden 1978), being a familiar feature of both the work and pastime activities of an increasing number of individuals. It is frequently the case that a degree of subjective interaction is required for the successful operation of such VDU-based equipment. It thus becomes apparent that a televised approach to visual performance assessment, in clinical surroundings, is an increasingly feasible proposition.

In addition, certain wider potential applications of such a system might be considered. With reference to the studies of Weston (1945) and of other workers discussed previously (Chapter 3; Section 3.2, pages 52-61), the visual task posed by the broken ring (this being an example of an easily and accurately generated target stimulus) would lend itself to the ready simulation of particular aspects of a task or work environment. Such aspects could include the determination of the optimum level of lighting required for a given task or, conversely, could aid in the screening of operatives prior to engaging them upon a job requiring a particular degree of precision or skill. A further application which could be suggested would be to investigate the effects of a course or dosage level of a particular medication, or even the effects of drug or alcohol intoxication, in order to determine levels at which performance, manual dexterity or co-ordination

became impaired.

10.2B Project Phase II : Visual Performance with Soft Contact Lenses

The results of the validation studies indicated that the TV system provided a suitable approach to the investigation of visual performance (vide Section 7.4, pages 183 - 201). It was the intention in the second stage of the research project to utilize the established system in an inquiry into visual performance aspects of the adaptational period (fixed as the first four weeks) of regular daily soft contact lens wear in the experimentally naïve subject.

The subjects participating in the final study were broadly divided into two groups : firstly, those that retained a good, stable $^{6}/_{4}$ level of acuity+ with an optimally-fitting soft contact lens as well as with their best spectacle correction; and secondly, those whose soft contact lens vision, over the course of the four week study, was fluctuating and certainly not as sharply defined as with their spectacle lenses but who could nevertheless still just read the $^{6}/_{4}$ line if several attempts were permitted. This selection and division of subjects was in an attempt to simulate the conditions which were at the basis of the observations cited in the literature (vide Section

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+ All visual acuities were subjectively determined at 6m, under monocular conditions, on an internally illuminated Landolt chart conforming to B.S. 4274 : 1968.

1.3Di, pages 15 - 16) : some soft contact lens wearers achieved a good level of Snellen acuity, when pressed, in the consulting room, yet still complained of a transient blurring, or fluctuating, 'watery' vision with their apparently well-fitting soft contact lenses.

It should be noted here that any suggestions made by the investigator over the course of the study that soft contact lens wear should be abandoned, a full cash refund of their fee paid, and that spectacle wear be resumed, were firmly resisted by all of the subjects experiencing fluctuating vision. This subjective tolerance was again revealed upon consideration of these subjects' assessments of the stability and quality of their soft contact lens vision, as indicated on the questionnaire completed at each of the six data collection visits. In no instance were either of these features regarded as unsatisfactory or unacceptable. This suggests that stability or quality of vision obtained with a soft contact lens, whether determined objectively (TV system) or subjectively (questionnaire), is not the sole consideration with regard to subjective acceptability. There must be other features which the subject has recourse to such that he can somehow optimize his visual performance with this particular form of refractive aid. This speculative suggestion will now be discussed further.

With reference to Chapter 9 (Section 9.1B, pages 240 - 242), following the several correlation analyses (i.e., those statistical correlations as summarized in Table 18, page 238) of the three defined areas of data generated over the course of the fourth study (i.e., the subjective TV responses, the response latencies and the blink activity

data) the constancy of results (Appendix IV : Table 35C, pages 397 - 400) between the two groups of subjects (i.e., constant versus fluctuating soft contact lens vision) was striking. In addition, regardless of the sex of the subject, the magnitude or type of the ocular refraction, or the precise soft lens fit, three experimental factors remained consistently statistically significant (vide page 240) : TV score; response latency; blink rate when stimulus off (i.e., during that period immediately following the subjective response).

On the basis of these experimental results, the earlier inference (pages 240 - 242) that subjective strategy can alter with prevailing observation conditions such that performance is optimized, must now be considered further. The precise form that this inter-relationship takes can only be conjectured upon in this present discussion, but on the basis of the sum correlation results it seems reasonable to assume some degree of equilibrium, as indicated in Figure 25 (page 241). This is clearly an area for further work, but it is suggested here that, in a manner analogous to homoeostasis‡, the new soft contact lens wearers in the fourth study sought to maintain an equilibrium with regard to the level of visual performance by a tendency to

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‡ Homoeostasis : The maintenance of a dynamically stable state within a system by means of internal regulatory processes that tend to counteract any disturbance of the stability by external forces or influences; the state of stability so maintained. - The Oxford English Dictionary (Supplement), Oxford University Press 1976.

compensate for changes disruptive to vision. The correctness of subjective response data, as generated with the TV system, is clearly only one part of the input to the overall performance level : the elements of response latency and also blink rate in the immediate post-response period must also be considered.

A model comprising the three overlapping spheres of activity may be constructed (Figure 26, page 252) to represent the dynamic character of subjective strategy. In this model the three spheres retain a constant inter-relationship (as represented by the shaded area 'P' in Figure 26, page 252) : i.e., the area P will remain constant although its constituents will change. The contention advanced here is that, in the absence of any further available evidence, it is the measure represented by this common area P which may be considered as the index of 'visual performance' of a soft contact lens wearer.

It will be remarked upon here that the model proposed to account for the optimization of a soft contact lens wearer's visual performance also bears out certain intuitive suppositions : viz, in order to maximize his TV score (the tangible result of good visual performance) a subject who is perhaps aware that his soft contact lenses give him less than perfect acuity will not only increase his response latency in the hope of making a correct response, but will also confine his eye-blink activity to the least detrimental (as far as his response is concerned) of the three time periods (before, during, after) associated with stimulus presentation.

The operation of a dynamic equilibrium as hypothesized here serves to confound any investigation of soft contact lens visual performance. Despite careful attention to detail in the design of a system to

FIGURE 26: A model to represent the dynamic character of subjective strategy, proposed to account for the optimization of visual performance by the soft contact lens wearer

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In summary (refer to text, Section 102B, page 251), the three elements shown in the Figure contribute to the soft contact lens wearer's index of visual performance, P

It will be noted that the three spheres of subjective activity in the two-dimensional drawing of the model are represented as being of equal importance. It is certainly possible (though not proven here) that this is not in fact the case. Furthermore, the spheres may be subject to forces of bias and thus the area of overlap associated with each pair of spheres, and also the common area of overlap P, may not be as symmetrical as shown in the Figure. The double-ended arrows superimposed upon the three identically drawn spheres should serve to remind the reader of the uncertainty of the precise inter-relationship between the three elements.

The limitations ('domain') of the model of the soft contact lens wearer's visual performance should also be considered, inasmuch as there must conceivably be a point where either the motivation of the subject or the quality of lens fit is such that P cannot be maintained constant. (It is suggested that motivation can usually be assumed to be high, and of course the tolerance associated with the quality of lens fit is determined in large part by the standard of the contact lens practitioner.)

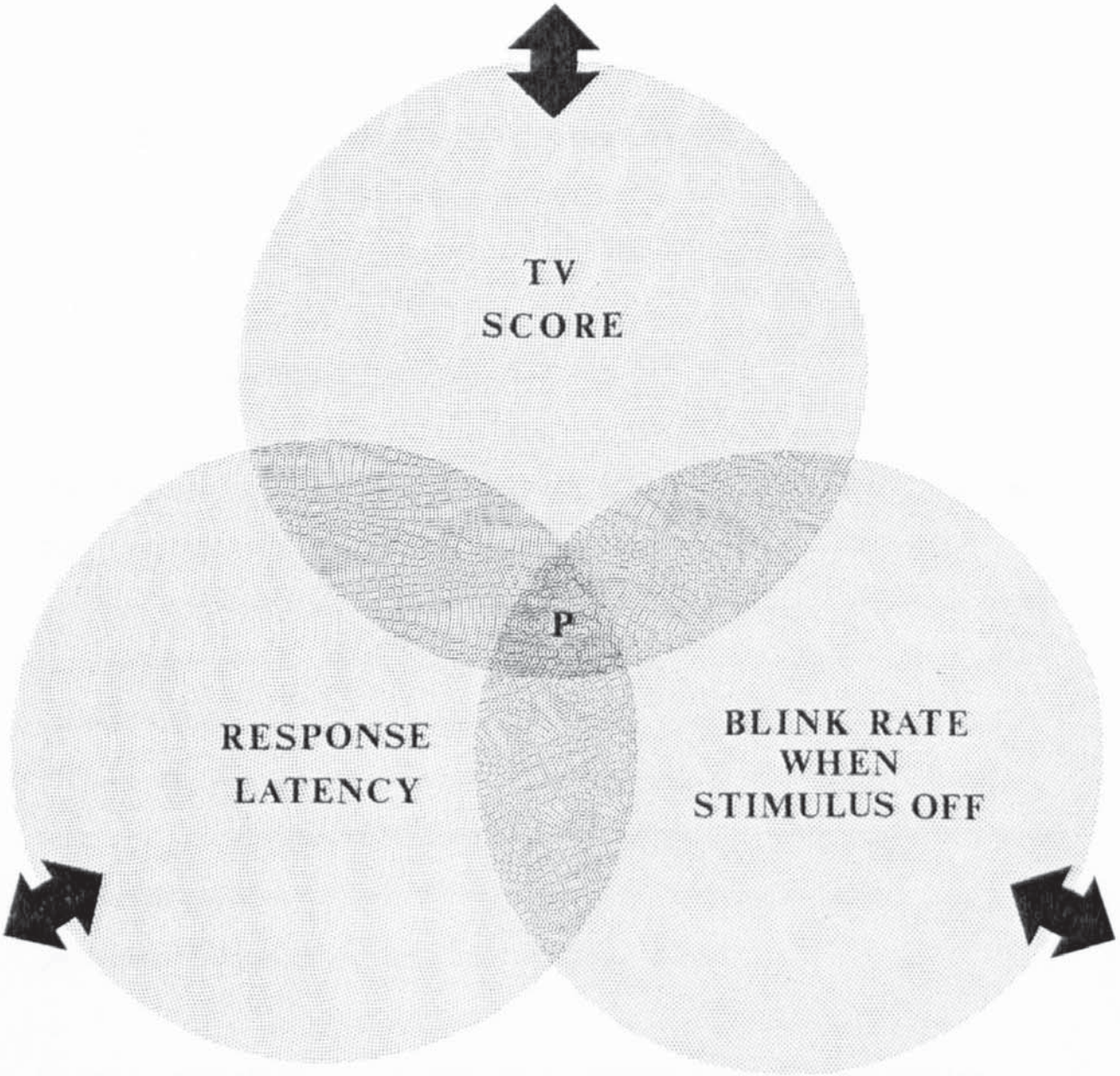
assess vision (visual performance) on a more accurate basis than the conventional Snellen letter chart (by using, for example, a psychophysical test procedure, or testing at lowered stimulus contrast levels), the precise quantification of soft contact lens visual performance remains elusive. The point has already been made (Section 10.1, page 244) that the devising of more elaborate instrumentation or experimental approaches would probably be at the expense of clinical application in optometric practice. Also, it is by no means certain that such refinements could further define the components of a self-limiting system such as that hypothesized, where the level of a subject's visual performance is under the continuous control of a negative/positive feedback strategy.

10.3 Concluding Remarks

The original contribution of the work presented here is the finding that the new soft hydrophilic contact lens wearer, in the first month of regular daily lens wear, strives to maintain an equilibrium with regard to his level of visual performance : unfortunately, the dynamic nature of the subjective strategy model which is proposed (Figure 26, page 252) frustrates the precise quantification of this feature. To the author's knowledge there do not exist any previously published reports of such a comprehensive investigation of visual performance aspects of soft contact lens wear.

It would certainly be interesting to pursue further this working hypothesis of a dynamic or 'homoeostatic' model of visual performance. However, such investigations would clearly require optimum accuracy of measurement of all parameters, the aim being to see whether assessment

FIG. 26



of this dynamic equilibrium could be carried out in routine optometric practice.

Despite the remarks previously made with regard to the (low) level of reliability of a subject's assessment of his own performance (vide Sections 7.4Aii and 9.1B, pages 187 and 242, respectively : Lythgoe 1932), it might well be that subjective impressions, taken in conjunction with the Snellen or Landolt visual acuity level, could prove to be as reliable a guide to performance with a soft contact lens as more elaborate approaches, especially within the clinical environment of the consulting room. A certain amount of credence is lent to this statement when one considers that in the final study, despite being aware that vision could be stable and more sharply defined with spectacle lenses, the group of subjects with fluctuating acuity still indicated that stability and quality of vision was quite acceptable and were resistant to any suggestions that they might abandon soft contact lens wear. Such is the nature of the problem associated with the investigation of visual performance of the human eye with soft hydrophilic contact lenses .

APPENDICES

APPENDIX 1

STUDY NO. 1

Tabulations of the Experimental Data and the Statistical Analyses

Table 19: STUDY NO. 1 - Subjective TV Scores, corrected for guessing (vide APPENDIX V: pages 426-430), summed over two identical runs at selected control settings of the TV system.

(Checklist of TV system control settings: APPENDIX XIIIA: page 501).

N = 21 subjects.

TABLE 19:

Subject No.			STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	CONTRAST LEVEL	- 1	8.00	8.00	20.00	20.00	14.67	20.00	20.00	20.00	2.67	17.33
		+ 1	3.33	14.67	18.67	17.33	18.67	20.00	20.00	20.00	5.33	14.67
		- 2	4.00	16.00	20.00	20.00	18.67	18.67	20.00	20.00	6.67	16.00
		+ 2	8.00	9.33	20.00	20.00	20.00	20.00	20.00	20.00	2.67	12.00
		- 3	2.67	13.33	18.67	20.00	18.67	20.00	20.00	20.00	5.33	12.00
		+ 3	2.00	10.67	17.33	18.67	20.00	20.00	20.00	20.00	4.00	10.67
		- 4	0	2.00	17.33	18.67	12.00	20.00	20.00	20.00	2.00	6.67
		+ 4	5.33	2.00	18.67	20.00	14.67	18.67	20.00	20.00	3.33	8.00
		- 5	0.67	0	12.00	17.33	5.33	9.33	20.00	20.00	0	0.67
		+ 5	0.67	0.67	17.33	20.00	8.00	16.00	20.00	20.00	0.67	1.33
		- 6	0	0	5.33	16.00	3.33	8.67	20.00	20.00	3.33	2.00
		+ 6	4.00	0.67	8.00	20.00	2.00	8.00	20.00	20.00	0	0.67
2	CONTRAST LEVEL	- 1	3.33	6.67	20.00	20.00	16.00	20.00	20.00	20.00	1.33	10.67
		+ 1	3.33	9.33	20.00	18.67	18.67	20.00	20.00	20.00	0	5.33
		- 2	4.00	4.67	18.67	20.00	18.67	18.67	20.00	20.00	0	4.00
		+ 2	1.33	8.00	20.00	20.00	16.00	20.00	20.00	20.00	0.67	12.00
		- 3	0	5.33	20.00	20.00	16.00	18.67	20.00	20.00	4.00	6.67
		+ 3	2.67	6.67	18.67	20.00	10.67	18.67	20.00	18.67	1.33	5.33
		- 4	4.00	0.67	20.00	20.00	10.67	17.33	20.00	20.00	0	5.33
		+ 4	0	0.67	20.00	20.00	8.00	16.00	20.00	20.00	0	10.66
		- 5	5.33	2.00	18.67	20.00	8.00	12.00	20.00	20.00	2.00	2.67
		+ 5	1.33	0.67	9.33	18.67	2.67	6.67	20.00	20.00	2.67	2.67
		- 6	1.33	0	6.67	13.33	0.67	5.33	20.00	20.00	2.67	6.00
		+ 6	2.67	2.00	6.67	12.00	3.33	3.33	20.00	20.00	2.67	6.67
3	CONTRAST LEVEL	- 1	2.00	2.67	16.00	18.67	10.67	13.33	20.00	20.00	2.67	8.00
		+ 1	0.67	9.33	17.33	18.67	16.00	16.00	20.00	20.00	2.00	0.67
		- 2	0	6.67	20.00	20.00	8.00	16.00	20.00	20.00	0.67	1.33
		+ 2	5.33	6.00	17.33	20.00	8.00	16.00	20.00	20.00	5.33	2.00
		- 3	0.67	2.00	14.67	16.00	4.00	13.33	20.00	20.00	0.67	2.00
		+ 3	0	6.67	16.00	20.00	10.67	14.67	20.00	20.00	2.00	2.00
		- 4	3.33	5.33	20.00	18.67	6.67	12.00	20.00	20.00	0.67	3.33
		+ 4	6.67	2.67	17.33	18.67	10.67	16.00	20.00	20.00	0	9.33
		- 5	2.67	2.00	8.00	18.67	4.00	0.67	16.00	20.00	0	0
		+ 5	0	0.67	10.67	13.33	5.33	9.33	20.00	20.00	2.00	0.67
		- 6	1.33	0.67	2.67	9.33	4.67	4.00	18.67	20.00	0	0
		+ 6	0	2.00	1.33	13.33	1.33	0	18.67	20.00	2.00	1.33

TABLE 19: continued

Subject No.			STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
4	CONTRAST LEVEL	- 1	0.67	16.00	20.00	20.00	17.33	20.00	20.00	20.00	4.00	14.67
		+ 1	0.67	18.67	20.00	20.00	18.67	20.00	20.00	20.00	2.00	12.00
		- 2	2.00	8.00	20.00	20.00	20.00	20.00	20.00	20.00	4.67	10.67
		+ 2	0	8.00	20.00	20.00	17.33	17.33	20.00	20.00	1.33	2.67
		- 3	2.67	10.67	20.00	20.00	17.33	20.00	20.00	20.00	2.00	12.00
		+ 3	5.33	10.67	20.00	20.00	18.67	20.00	20.00	20.00	5.33	8.00
		- 4	2.00	3.33	20.00	18.67	3.33	20.00	20.00	20.00	0.67	0.67
		+ 4	5.33	2.67	20.00	20.00	9.33	18.67	20.00	20.00	0.67	4.00
		- 5	0	1.33	20.00	16.00	9.33	17.33	20.00	20.00	0.67	0
		+ 5	0.67	2.67	16.00	18.67	9.33	18.67	20.00	20.00	3.33	3.33
		- 6	3.33	4.00	3.33	13.33	5.33	0.67	20.00	20.00	0	8.67
		+ 6	2.67	0.67	8.00	17.33	2.67	2.00	18.67	20.00	2.00	5.33
5	CONTRAST LEVEL	- 1	0	5.33	9.33	12.00	2.67	8.00	18.67	20.00	0	0.67
		+ 1	0	1.33	2.67	17.33	0.67	4.67	16.00	18.67	0	0
		- 2	0	3.33	10.67	16.00	1.33	8.00	20.00	20.00	0	0.67
		+ 2	0	0	9.33	12.00	1.33	5.33	20.00	20.00	0	0
		- 3	0.67	0	10.67	13.33	0.67	12.00	18.67	20.00	0	0.67
		+ 3	0	0	4.00	14.67	1.33	4.00	18.67	20.00	0	0.67
		- 4	3.33	2.67	5.33	12.00	3.33	0.67	14.67	20.00	0.67	0.67
		+ 4	2.67	0	3.33	6.67	0	4.67	13.33	20.00	0	0
		- 5	0	0	0.67	6.00	0.67	0	10.67	20.00	0	0
		+ 5	0	0	0	0.67	0	0	3.33	20.00	0	0
		- 6	3.33	0	0	4.67	0	0.67	5.33	8.00	0	3.33
		+ 6	0	0	0	0	2.00	2.67	4.00	5.33	0	0
6	CONTRAST LEVEL	- 1	0	5.33	17.33	20.00	6.67	8.00	20.00	20.00	4.67	2.00
		+ 1	5.33	1.33	14.67	17.33	3.33	12.00	20.00	20.00	0.67	5.33
		- 2	2.00	5.33	18.67	20.00	5.33	16.00	20.00	20.00	0.67	0
		+ 2	4.67	6.00	20.00	18.67	8.67	17.33	20.00	20.00	1.33	3.33
		- 3	0.67	0.67	12.00	20.00	0.67	12.00	20.00	20.00	4.00	5.33
		+ 3	3.33	0	16.00	20.00	5.33	10.67	20.00	20.00	0	2.00
		- 4	4.67	0.67	14.67	14.67	0.67	4.67	20.00	20.00	0	0.67
		+ 4	4.00	0	14.67	18.67	9.33	9.33	20.00	20.00	0	2.67
		- 5	0	0	6.67	10.67	0.67	2.00	20.00	20.00	0.67	0.67
		+ 5	0	0	13.33	14.67	0	0.67	20.00	20.00	0	0
		- 6	0	0	0	2.67	0	2.00	16.00	20.00	0	0
		+ 6	0.67	0	2.67	6.67	0.67	2.00	14.67	17.33	0	0

TABLE 19: continued

Subject No.		CONTRAST LEVEL	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
7	-	1	0	0	17.33	18.67	6.67	13.33	20.00	20.00	0.67	0
	+		0	0	18.67	20.00	6.67	17.33	18.67	20.00	4.67	0
	-	2	0.67	0	17.33	18.67	6.67	14.67	18.67	20.00	2.00	4.00
	+		0	5.33	18.67	20.00	3.33	18.67	20.00	20.00	2.67	0.67
	-	3	0.67	0.67	16.00	18.67	0	16.00	20.00	20.00	0	1.33
	+		0	4.00	16.00	17.33	0.67	9.33	20.00	20.00	0	4.67
	-	4	0	5.33	17.33	17.33	4.00	8.00	20.00	20.00	0.67	3.33
	+		0	0.67	12.00	17.33	1.33	5.33	17.33	20.00	0	0.67
	-	5	2.00	0.67	8.00	17.33	2.67	4.00	20.00	20.00	0	0.67
	+		0	5.33	13.33	17.33	0	4.00	20.00	20.00	0	0
	-	6	0	0	3.33	4.00	0	0	17.33	20.00	0	0
	+		0	0	2.00	8.00	0	2.00	12.00	16.00	0	0
8	-	1	0.67	7.33	13.33	18.67	8.00	9.33	20.00	20.00	0	4.00
	+		0	0.67	20.00	20.00	2.67	10.67	20.00	20.00	0	0
	-	2	2.67	2.67	10.67	18.67	2.00	10.67	20.00	20.00	0.67	1.33
	+		0	1.33	14.67	17.33	0	4.67	20.00	20.00	0	2.67
	-	3	0	0	12.00	18.67	4.00	9.33	20.00	20.00	0	0
	+		0	4.67	9.33	18.67	0.67	5.33	20.00	20.00	0	2.00
	-	4	1.33	0.67	4.00	17.33	0.67	0.67	20.00	20.00	3.33	1.33
	+		0.67	0.67	8.00	8.00	0.67	3.33	17.33	20.00	0	0
	-	5	0	0	0.67	12.00	0	2.67	17.33	20.00	0	0
	+		0	0	2.00	2.67	0	0	12.00	18.67	0	0
	-	6	0	4.00	0.67	0.67	1.33	0	6.00	17.33	0.67	0
	+		0	0	0	0.67	0	0	4.00	17.33	0	0
9	-	1	0	0.67	20.00	20.00	4.00	14.67	20.00	20.00	0	2.00
	+		0	0	20.00	20.00	0	10.67	20.00	20.00	0	0
	-	2	0	0	18.67	20.00	0	6.67	20.00	20.00	0	0
	+		0	0	20.00	20.00	0	7.33	20.00	20.00	0	0
	-	3	0	0	14.67	18.67	2.00	3.33	20.00	20.00	0	0
	+		0	0	17.33	18.67	0	2.00	20.00	20.00	0	0
	-	4	0	0	6.67	17.33	0	0	18.67	20.00	0	0
	+		0	0	0.67	20.00	0	0	20.00	20.00	0	0
	-	5	0	0	0	9.33	0	0	20.00	17.33	0	0
	+		0	0	0	12.00	0	0	18.67	20.00	0	0
	-	6	0	0	0	0	0	0	16.00	17.33	0	0
	+		0	0	0	0	0	0	4.00	18.67	0	0

Table 19: Continued

Subject No.			STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
10	CONTRAST LEVEL -	1	0	0	16.00	18.67	3.33	10.67	20.00	20.00	0	2.00
	+		0	4.00	16.00	18.67	5.33	13.33	20.00	20.00	0	2.67
	-	2	0	2.67	16.00	17.33	6.67	12.00	20.00	20.00	0.67	4.00
	+		0	1.33	18.67	20.00	3.33	8.00	20.00	20.00	0	2.67
	-	3	0	0.67	17.33	20.00	1.33	9.33	20.00	20.00	0.67	5.33
	+		0	3.33	16.00	20.00	0.67	8.00	20.00	20.00	0	0
	-	4	0	0.67	14.67	17.33	2.67	10.67	20.00	20.00	0	0
	+		0	2.00	9.33	20.00	2.67	12.00	18.67	20.00	0	0
	-	5	0	0	6.67	12.00	0	2.00	16.00	20.00	0	0
	+		0	0	0.67	9.33	0	0.67	17.33	20.00	0	0
	-	6	0	0	0	0.67	0	0	13.33	18.67	0	0
	+		0	0	0	2.67	0	0	8.00	16.00	0	0
11	CONTRAST LEVEL -	1	0	0	16.00	20.00	0	10.67	18.67	20.00	0	0
	+		0	0	10.00	18.67	2.00	4.67	20.00	20.00	0	0
	-	2	2.00	0.67	12.00	18.67	8.00	13.33	20.00	20.00	0.67	0
	+		0	0.67	10.67	18.67	4.00	12.00	20.00	20.00	1.33	2.00
	-	3	0	0	10.67	20.00	0	0.67	20.00	20.00	0	0
	+		0	0	12.00	18.67	0	4.67	18.67	20.00	0	0
	-	4	0	0	9.33	17.33	3.33	2.00	18.67	20.00	0	0
	+		0	0	4.00	16.00	0.67	8.00	18.67	20.00	0	0
	-	5	0	0	8.00	14.67	0	4.67	20.00	18.67	0	0
	+		0	0	2.00	8.00	0	0	17.33	18.67	0	0
	-	6	0	0	0	0	0	0	14.67	20.00	0	0
	+		0	0	0	o.67	0	0	6.67	16.00	0	0
12	CONTRAST LEVEL -	1	0.67	9.33	20.00	20.00	16.00	20.00	20.00	20.00	0	13.33
	+		2.67	5.33	18.67	18.67	20.00	20.00	20.00	20.00	1.33	13.33
	-	2	4.00	2.00	20.00	20.00	16.00	20.00	20.00	20.00	5.33	6.67
	+		3.33	4.67	20.00	20.00	12.00	16.00	20.00	20.00	0.67	5.33
	-	3	2.00	0.67	18.67	20.00	14.67	20.00	20.00	20.00	2.67	0
	+		0	5.33	20.00	20.00	12.00	20.00	20.00	20.00	0	0.67
	-	4	2.00	3.33	14.67	17.33	8.00	13.33	20.00	18.67	0.67	1.33
	+		2.00	4.67	17.33	18.67	2.00	18.67	20.00	20.00	1.33	4.00
	-	5	0.67	0	16.00	14.67	0.67	12.00	20.00	20.00	0	0
	+		0	0.67	17.33	16.00	0.67	5.33	20.00	20.00	0.67	0
	-	6	0	0	6.67	17.33	0	0	20.00	18.67	0	0
	+		0	0	2.67	12.00	0	3.33	20.00	20.00	0	0

Table 19: continued

Subject No:			STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
13	CONTRAST LEVEL	- 1	6.67	2.00	17.33	20.00	10.67	20.00	20.00	20.00	0	5.33
		+ 1	2.00	5.33	20.00	18.67	10.67	20.00	20.00	20.00	2.00	1.33
		- 2	0.67	0.67	20.00	20.00	8.00	20.00	20.00	20.00	0	0
		+ 2	0.67	2.67	20.00	20.00	9.33	18.67	20.00	20.00	0	4.00
		- 3	0.67	0	17.33	17.33	3.33	18.67	20.00	20.00	0.67	0.67
		+ 3	0	3.33	20.00	17.33	10.67	18.67	20.00	20.00	0	6.67
		- 4	0	0	16.00	20.00	0.67	9.33	20.00	20.00	0	0
		+ 4	0	0	16.00	20.00	0	8.00	20.00	20.00	0	0
		- 5	0	0	12.00	13.33	0	2.67	20.00	20.00	0	0
		+ 5	0	0	10.67	18.67	0	0	20.00	20.00	0	0
		- 6	0	0	0	3.33	0	0	14.67	17.33	0	0
		+ 6	0	0	0	9.33	0	0	16.00	17.33	0	0
14	CONTRAST LEVEL	- 1	0	5.33	20.00	20.00	5.33	17.33	20.00	20.00	0	2.00
		+ 1	0	4.67	20.00	18.67	13.33	10.67	20.00	20.00	4.00	3.33
		- 2	0	3.33	12.00	18.67	8.00	16.00	20.00	20.00	0	0
		+ 2	2.00	4.00	16.00	20.00	8.00	13.33	18.67	20.00	2.00	3.33
		- 3	0.67	3.33	20.00	20.00	5.33	8.00	20.00	20.00	2.00	1.33
		+ 3	2.00	4.00	18.67	17.33	8.00	13.33	20.00	20.00	2.67	3.33
		- 4	0	0.67	8.00	17.33	2.00	6.67	20.00	20.00	0	0.67
		+ 4	0	0.67	10.67	18.67	6.67	10.67	20.00	20.00	0	0.67
		- 5	0	0	0	13.33	0	3.33	20.00	18.67	0	0
		+ 5	0	0	6.67	17.33	0	0	20.00	20.00	0	0
		- 6	0	0	2.67	4.00	0	0	9.33	20.00	0	0
		+ 6	0	0	0.67	9.33	0	0	13.33	20.00	0	0
15	CONTRAST LEVEL	- 1	2.00	2.67	20.00	18.67	9.33	14.67	18.67	18.67	2.00	4.00
		+ 1	5.33	0.67	14.67	20.00	10.67	18.67	20.00	20.00	0	1.33
		- 2	0	0	14.67	20.00	0	16.00	20.00	20.00	0.67	0.67
		+ 2	0	2.00	16.00	18.67	8.00	10.67	20.00	20.00	0	0.67
		- 3	0	0	13.33	16.00	0.67	13.33	20.00	20.00	0	0.67
		+ 3	0.67	3.33	13.33	20.00	2.67	9.33	18.67	20.00	4.67	0
		- 4	0	0	10.67	13.33	0.67	4.00	18.67	20.00	0	0
		+ 4	0	0	5.33	14.67	2.00	9.33	18.67	20.00	0	0
		- 5	0	0	4.00	12.00	0	0	13.33	20.00	0	0
		+ 5	0	0	3.33	8.00	0	0.67	16.00	20.00	0	0
		- 6	0	0	0	2.00	0	0	13.33	20.00	0	0
		+ 6	0	0	0	2.00	0	0	0.67	17.33	0	0

Table 19: continued

Subject No:		CONTRAST LEVEL	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
16	-	1	3.33	9.33	20.00	20.00	4.00	14.67	20.00	20.00	4.00	0.67
	+	1	0	0	16.00	20.00	14.67	17.33	20.00	20.00	5.33	2.67
	-	2	2.00	2.67	20.00	20.00	9.33	17.33	20.00	20.00	4.00	2.67
	+	2	0.67	2.00	18.67	20.00	16.00	17.33	20.00	20.00	5.33	1.33
	-	3	0.67	1.33	18.67	20.00	1.33	13.33	20.00	20.00	3.33	4.67
	+	3	0	0	20.00	18.67	9.33	17.33	20.00	20.00	2.00	3.33
	-	4	0	0	16.00	20.00	8.00	13.33	20.00	20.00	0	2.67
	+	4	0	0	18.67	18.67	2.67	8.00	20.00	20.00	0	0
	-	5	0	2.00	13.33	8.00	0	2.67	20.00	20.00	0	0
	+	5	0	0	9.33	18.67	0.67	3.33	20.00	20.00	0	0
	-	6	2.00	0	0.67	2.67	2.00	0	20.00	20.00	6.00	0
	+	6	0	0	4.00	10.67	0	0	10.67	20.00	2.00	0
17	-	1	0	4.00	20.00	16.00	17.33	18.67	20.00	20.00	0	4.00
	+	1	0	9.33	20.00	18.67	20.00	20.00	20.00	20.00	0	9.33
	-	2	0	2.00	20.00	20.00	13.33	20.00	20.00	20.00	0	5.33
	+	2	0	2.67	18.67	18.67	5.33	17.33	20.00	20.00	0	4.00
	-	3	0	0	20.00	20.00	14.67	18.67	20.00	20.00	0	0
	+	3	0	0.67	17.33	18.67	13.33	17.33	20.00	20.00	0	6.67
	-	4	0	0	16.00	20.00	4.67	14.67	20.00	20.00	0	0
	+	4	0	0.67	16.00	18.67	2.67	12.00	20.00	20.00	0	0
	-	5	0	0	12.00	18.67	0	8.00	20.00	20.00	0	0
	+	5	0	0	16.00	20.00	0	6.67	20.00	20.00	0	0
	-	6	0	0	0.67	6.67	0	0	17.33	17.33	0	0
	+	6	0	0	0.67	6.67	0	0	13.33	20.00	0	0
18	-	1	0.67	4.67	18.67	20.00	12.00	16.00	20.00	20.00	2.00	5.33
	+	1	0.67	5.33	18.67	20.00	12.00	18.67	20.00	20.00	2.67	2.67
	-	2	1.33	8.00	18.67	18.67	13.33	20.00	20.00	20.00	0	2.00
	+	2	4.67	4.00	18.67	20.00	12.00	20.00	20.00	20.00	0.67	5.33
	-	3	0	1.33	17.33	20.00	5.33	16.00	20.00	20.00	3.33	0
	+	3	0	6.67	17.33	18.67	8.00	16.00	20.00	20.00	2.00	5.33
	-	4	5.33	1.33	17.33	18.67	0.67	12.00	20.00	18.67	2.00	0
	+	4	1.33	0	16.00	17.33	4.00	16.00	20.00	20.00	4.67	2.67
	-	5	2.00	0	6.67	14.67	0.67	12.00	20.00	20.00	0.67	0.67
	+	5	4.00	4.67	16.00	16.00	2.00	8.00	20.00	20.00	0.67	0
	-	6	0	0	5.33	10.67	3.33	0	17.33	20.00	0	0
	+	6	0	0	4.67	16.00	0.67	2.00	18.67	20.00	0	0

Table 19: continued

Subject No:			STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
19	CONTRAST LEVEL	- 1	0	0	20.00	20.00	13.33	20.00	20.00	20.00	5.33	8.00
		+ 1	4.00	5.33	18.67	20.00	13.33	18.67	20.00	20.00	0	2.67
		- 2	0.67	3.33	18.67	18.67	12.00	17.33	20.00	20.00	2.00	3.33
		+ 2	0.67	5.33	20.00	20.00	9.33	18.67	20.00	20.00	0	0.67
		- 3	3.33	2.00	17.33	18.67	8.00	18.67	20.00	20.00	1.33	4.67
		+ 3	3.33	4.67	18.67	20.00	12.00	13.33	20.00	20.00	0	3.33
		- 4	0	0.67	17.33	20.00	5.33	10.67	20.00	20.00	0	0
		+ 4	0	2.00	16.00	20.00	5.33	14.67	20.00	20.00	0	0.67
		- 5	0	0	4.00	10.67	2.67	0	20.00	20.00	0	0
		+ 5	0	0	0.67	12.00	0.67	6.67	18.67	18.67	0	0
		- 6	0	0	5.33	4.00	0	4.67	18.67	20.00	0	0
		+ 6	0	0	0	9.33	0	0	18.67	20.00	0	0
20	CONTRAST LEVEL	- 1	0	4.00	20.00	20.00	6.67	18.67	20.00	20.00	5.33	4.00
		+ 1	3.33	8.00	20.00	20.00	17.33	20.00	20.00	20.00	0	5.33
		- 2	0	2.67	20.00	20.00	6.67	20.00	20.00	20.00	2.67	6.67
		+ 2	2.67	3.33	20.00	20.00	17.33	17.33	20.00	20.00	2.00	2.00
		- 3	4.00	0.67	16.00	18.67	5.33	14.67	20.00	20.00	0	4.67
		+ 3	3.33	4.00	16.00	20.00	6.00	13.33	20.00	20.00	0.67	0.67
		- 4	0	2.67	18.67	20.00	1.33	16.00	20.00	20.00	0.67	0.67
		+ 4	0.67	0.67	17.33	20.00	0.67	10.67	20.00	20.00	0	0.67
		- 5	0	1.33	12.00	18.67	4.67	10.67	20.00	20.00	0	0
		+ 5	0	0	9.33	14.67	2.00	4.67	18.67	20.00	0	0
		- 6	0	0	0	4.67	2.00	0	17.33	20.00	0	0
		+ 6	0	0	0.67	4.00	0	0	10.67	17.33	0	0
21	CONTRAST LEVEL	- 1	0.67	0.67	18.67	20.00	5.33	20.00	20.00	20.00	0.67	4.00
		+ 1	0	0.67	18.67	20.00	10.67	20.00	20.00	20.00	2.67	4.00
		- 2	0	4.00	20.00	20.00	5.33	16.00	20.00	20.00	0	0
		+ 2	3.33	3.33	20.00	20.00	4.00	16.00	17.33	20.00	4.67	0
		- 3	2.00	3.33	16.00	20.00	1.33	13.33	20.00	20.00	0	0
		+ 3	0	0	16.00	18.67	5.33	16.00	20.00	20.00	2.00	0.67
		- 4	0	1.33	14.67	17.33	4.67	9.33	20.00	20.00	2.00	0
		+ 4	2.00	4.00	13.33	18.67	6.67	9.33	20.00	20.00	0.67	4.00
		- 5	0	0	2.00	14.67	0.67	3.33	20.00	20.00	0	0.67
		+ 5	0	0	6.67	18.67	0.67	0	20.00	20.00	0	0
		- 6	0	0	5.33	2.67	0	0.67	17.33	20.00	0.67	0.67
		+ 6	0	0.67	0	5.33	0	0	8.00	20.00	0	0

Table 20: STUDY NO. 1 - Summary table, three-way analysis of variance (completely crossed design).

(Refer to Table 11: page 164, and APPENDIX VIA: pages 432-434).

Table 20A: Main groups of subjects (N = 21)- various acuity levels.

Table 20B: Sub-group of subjects (N = 10)- uniform acuity level.

Table 20A: Main Group of Subjects (N = 21) - various acuity levels.

SOURCE OF VARIATION			SUM SQUARES	df	MEAN SQUARE	F*
	A	Direction of Contrast	0.4071	1	0.4071	0.0414
Error	(AS)		196.5760	20	9.8288	
	B	Level of Contrast - %	15273.3585	5	3054.6717	387.1964
Error	(BS)		788.9205	100	7.8892	
	C	Level of Stimulus Angular Subtense	125742.4743	9	13971.3860	515.8566
Error	(CS)		4875.0940	180	27.0839	
	AB		20.9011	5	4.1802	1.3062
Error	(ABS)		320.0353	100	3.2004	
	AC		74.2492	9	8.2499	2.7172
Error	(ACS)		546.5081	180	3.0362	
	BC		10829.5317	45	240.6563	27.8437
Error	(BCS)		7778.7897	900	8.6431	
	ABC		296.3453	45	6.5855	2.097
Error	(ABCS)		2834.9496	900	3.1499	
	-	Subjects	8431.0638	20	421.5532	
		TOTAL	178009.2042	2519		

* F-ratios: Refer to TABLE 11: page 164.

Table 20B: Sub-group of Subjects (N = 10) - uniform acuity level.

SOURCE OF VARIATION			SUM SQUARES	df	MEAN SQUARE	F*
	A	Direction of Contrast	8.5666	1	8.5666	1.9676
Error	(AS)		39.1848	9	4.3539	
	B	Level of Contrast - %	8585.9993	5	1717.1999	315.8112
Error	(BS)		244.6842	45	5.4374	
	C	Level of Stimulus Angular Subtense	64859.4110	9	7206.6012	782.2865
Error	(CS)		746.1904	81	9.2122	
	AB		25.7483	5	5.1497	1.8831
Error	(ABS)		123.0607	45	2.7347	
	AC		78.0135	9	8.6682	2.8647
Error	(ACS)		245.0981	81	3.0259	
	BC		7122.0615	45	158.2680	28.7861
Error	(BCS)		2226.7161	405	5.4981	
	ABC		250.6591	45	5.5702	1.7563
Error	(ABCS)		1284.4467	405	3.1715	
	-	Subjects	859.0319	9	95.4480	
		TOTAL	86698.8720	1199		

* F-ratios: refer to Table 11: page 164.

Table 21: STUDY NO. 1 - Summary table, Tukey's analysis: Differences among means and levels of statistical significance.

(Refer to Table 11: page 164, and Table 20: pages 264-266)

Table 21A:* Factor B : Level of contrast - percent
Main group of subjects (N = 21) - various acuity levels.

Table 21B: Factor B : Level of contrast - percent
Sub-group of subjects (N = 10) - uniform acuity level.

Table 21C: Factor C : Level of Stimulus Angular Subtense
Main group of subjects (N = 21) - various acuity levels.

Table 21D: Factor C : Level of Stimulus Angular Subtense
Sub-group of subjects (N = 10) - uniform acuity level.

For each pairwise comparison between means in Tables 21A - 21D, the data are listed in a uniform sequence: the actual difference between the means, the calculated "wholly significant difference" (WSD) and an indication of the relevant statistical significance level.

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* Table 21A: Full calculations relating to this particular set of data are presented (pages 269-270) to illustrate the statistical procedure outline in APPENDIX VIIB: pages 455- 456, Tukey's Method for Multiple Comparison of Means.

Table 21A:† Factor B : Level of Contrast - per cent
Main group of subjects (N = 21) - various acuity levels.

	$\overline{B}_1$	$\overline{B}_2$	$\overline{B}_3$	$\overline{B}_4$	$\overline{B}_5$	$\overline{B}_6$
$\overline{B}_1$ = 11.4891	-	0.3746 (0.473)NS	1.1508 (0.621)**	2.4681 (0.642)**	4.6046 (0.656)**	6.9033 (0.667)**
$\overline{B}_2$ = 11.1145	-	-	0.7762 (0.587)**	2.0935 (0.621)**	4.2300 (0.642)**	6.5287 (0.656)**
$\overline{B}_3$ = 10.3383	-	-	-	1.3173 (0.587)**	3.4538 (0.621)**	5.7525 (0.642)**
$\overline{B}_4$ = 9.0210	-	-	-	-	2.1365 (0.587)**	4.4352 (0.621)**
$\overline{B}_5$ = 6.8845	-	-	-	-	-	2.2987 (0.587)**
$\overline{B}_6$ = 4.5858	-	-	-	-	-	-

** $p < 0.01$ * $p < 0.05$ NS not statistically significant

CONSTANTS : $s = \sqrt{7.889/(10 \times 2) \times 21} = 0.137$

$SR_{0.01} = 4.87$, $SR_{0.05} = 4.10$ (tabled values)

for V = 100 df and n = 6

† Full calculations relating to this particular set of data are presented overleaf, to illustrate the statistical procedure outlined in APPENDIX VIIB: pages 455-456, Tukey's Method for the Multiple Comparison of Means.

Calculations with reference to Table 21A and APPENDIX VIIB:

Tukey's Method for the Multiple Comparison of Means

Test (i) Mean B_1 vs B_6 $k = n = 6$

	1%	5%
SR (n)	4.87	4.10
SR (k)	4.87	4.10
SR (mean)	4.87	4.10
s	0.137	0.137
WSD	0.667	0.562

Actual difference $\bar{B}_1 \sim \bar{B}_6 = 6.9033 : p < 0.01$

Test (ii) Mean B_1 vs B_5 $k = n-1 = 5$

Mean B_2 vs B_6

	1%	5%
SR (n)	4.87	4.10
SR (k)	4.71	3.92
SR (mean)	4.79	4.01
s	0.137	0.137
WSD	0.656	0.549

Actual difference $\bar{B}_1 \sim \bar{B}_5 = 4.6046 : p < 0.01$
$\bar{B}_2 \sim \bar{B}_6 = 6.5287 : p < 0.01$

Test (iii) Mean B_1 vs B_4 $k = n-2 = 4$

Mean B_2 vs B_5

Mean B_3 vs B_6

	1%	5%
SR (n)	4.87	4.10
SR (k)	4.50	3.69
SR (mean)	4.69	3.90
s	0.137	0.137
WSD	0.642	0.534

Actual difference $\bar{B}_1 \sim \bar{B}_4 = 2.4681 : p < 0.01$
$\bar{B}_2 \sim \bar{B}_5 = 4.2300 : p < 0.01$
$\bar{B}_3 \sim \bar{B}_6 = 5.7525 : p < 0.01$

Test (iv) Mean B_1 vs B_3 k = n-3 = 3

B_2 vs B_4

B_3 vs B_5

B_4 vs B_6

	1%	5%
SR (n)	4.87	4.10
SR (k)	4.20	3.36
SR (mean)	4.54	3.73
s	0.137	0.137
WSD	0.621	0.511

Actual difference

$\bar{B}_1 \sim \bar{B}_3 = 1.1508 : p < 0.01$

$\bar{B}_2 \sim \bar{B}_4 = 2.0935 : p < 0.01$

$\bar{B}_3 \sim \bar{B}_5 = 3.4538 : p < 0.01$

$\bar{B}_4 \sim \bar{B}_6 = 4.4352 : p < 0.01$

Test (v) Mean B_1 vs B_2 k = n-4 = 2

B_2 vs B_3

B_3 vs B_4

B_4 vs B_5

B_5 vs B_6

	1%	5%
SR (n)	4.87	4.10
SR (k)	3.70	2.80
SR (mean)	4.29	3.45
s	0.137	0.137
WSD	0.587	0.473

Actual difference

$\bar{B}_1 \sim \bar{B}_2 = 0.3746 : NS$

$\bar{B}_2 \sim \bar{B}_3 = 0.7762 : p < 0.01$

$\bar{B}_3 \sim \bar{B}_4 = 1.3173 : p < 0.01$

$\bar{B}_4 \sim \bar{B}_5 = 2.1365 : p < 0.01$

$\bar{B}_5 \sim \bar{B}_6 = 2.2987 : p < 0.01$

NB. For explanation of abbreviations refer to APPENDIX VIIB: pages 455-456.

Table 21B: Factor B : Level of Constrast - per cent
Sub-Group of Subjects (N = 10) - uniform acuity level.

	$\overline{B}_1$	$\overline{B}_2$	$\overline{B}_3$	$\overline{B}_4$	$\overline{B}_5$	$\overline{B}_6$
$\overline{B}_1$ = 12.1302	-	0.7500 (0.737)**	1.4836 (0.782)**	3.0231 (0.809)**	5.2030 (0.828)**	7.6601 (0.843)**
$\overline{B}_2$ = 11.3802	-	-	0.7336 (0.585)*	2.2731 (0.782)**	4.4530 (0.809)**	6.9101 (0.828)**
$\overline{B}_3$ = 10.6466	-	-	-	1.5395 (0.737)**	3.7194 (0.782)**	6.1765 (0.809)**
$\overline{B}_4$ = 9.1071	-	-	-	-	2.1799 (0.737)**	4.6370 (0.782)**
$\overline{B}_5$ = 6.9272	-	-	-	-	-	2.4571 (0.737)**
$\overline{B}_6$ = 4.4701	-	-	-	-	-	-

** p < 0.01 * P < 0.05 NS Not statistically significant

CONSTANTS: $s = \sqrt{5.437/(10 \times 2) \times 10} = 0.165$

$SR_{0.01} = 5.11$, $SR_{0.05} = 4.23$ (tabled values)
for V = 45 df and n = 6

Table 21C: Factor C : Level of Stimulus Angular Subtense
Main Group of Subjects (N = 21) - various acuity levels.

	$\bar{C}_7$	$\bar{C}_6$	$\bar{C}_3$	$\bar{C}_2$	$\bar{C}_5$	$\bar{C}_4$	$\bar{C}_9$	$\bar{C}_{10}$	$\bar{C}_0$	$\bar{C}_8$
$\bar{C}_7$ = 19.6720	-	1.0872 (1.207)NS	3.7005 (1.588)**	7.0341 (1.607)**	9.5157 (1.642)**	14.2855 (1.668)**	17.3437 (1.691)**	17.3860 (1.709)**	18.6189 (1.724)**	18.6928 (1.738)**
$\bar{C}_6$ = 18.5848	-	-	2.6133 (1.476)**	5.9469 (1.558)**	8.4285 (1.607)**	13.1983 (1.642)**	16.2565 (1.668)**	16.2988 (1.691)**	17.5317 (1.709)**	17.6056 (1.724)**
$\bar{C}_3$ = 15.9715	-	-	-	3.3336 (1.476)**	5.8152 (1.558)**	10.5850 (1.607)**	13.6432 (1.642)**	13.6855 (1.668)**	14.9184 (1.691)**	14.9923 (1.709)**
$\bar{C}_2$ = 12.6379	-	-	-	-	2.4816 (1.476)**	7.2514 (1.558)**	10.3096 (1.607)**	10.3519 (1.642)**	11.5848 (1.668)**	11.6587 (1.691)**
$\bar{C}_5$ = 10.1563	-	-	-	-	-	4.7698 (1.476)**	7.8280 (.1558)**	7.8703 (1.607)**	9.1032 (1.642)**	9.1771 (1.668)**
$\bar{C}_4$ = 5.3865	-	-	-	-	-	-	3.0582 (1.476)**	3.1005 (1.558)**	4.3334 (1.607)**	4.4073 (1.642)**
$\bar{C}_9$ = 2.3283	-	-	-	-	-	-	-	0.0423 (1.207)NS	1.2752 (1.299)NS	1.3491 (1.353)NS
$\bar{C}_1$ = 2.2860	-	-	-	-	-	-	-	-	1.2329 (1.207)*	1.3068 (1.299)*
$\bar{C}_0$ = 1.0531	-	-	-	-	-	-	-	-	-	0.0739 (1.207)NS
$\bar{C}_8$ = 0.9792	-	-	-	-	-	-	-	-	-	-

** $p < 0.01$ * $p < 0.05$ NS not statistically significant

CONSTANTS: $s = \sqrt{27.084/(6 \times 2) \times 21} = 0.328$

$SR_{0.01} = 5.30$, $SR_{0.05} = 4.56$ (tabled values)

for V = 180 df and n = 10

Table 21D: Factor C : Level of Stimulus Angular Subtense
Sub-Group of Subjects (N = 10) - uniform acuity level.

	$\bar{C}_7$	$\bar{C}_6$	$\bar{C}_3$	$\bar{C}_2$	$\bar{C}_5$	$\bar{C}_4$	$\bar{C}_1$	$\bar{C}_9$	$\bar{C}_8$	$\bar{C}_0$
$\bar{C}_7$ = 19.8223	-	0.8833 (1.036)NS	3.3772 (1.348)**	6.3385 (1.392)**	8.5833 (1.422)**	14.1889 (1.446)**	17.9389 (1.465)**	18.0054 (1.482)**	18.8442 (1.497)**	18.9610 (1.510)**
$\bar{C}_6$ = 18.9390	-	-	2.4939 (1.276)**	5.4552 (1.348)**	7.7000 (1.392)**	13.3056 (1.422)**	17.0556 (1.446)**	17.1221 (1.465)**	17.9609 (1.482)**	18.0777 (1.497)**
$\bar{C}_3$ = 16.4451	-	-	-	2.9613 (1.276)**	5.2061 (1.348)**	10.8117 (1.392)**	14.5617 (1.422)**	14.6282 (1.446)**	15.5838 (1.465)**	15.5838 (1.482)**
$\bar{C}_2$ = 13.4838	-	-	-	-	2.2448 (1.276)**	7.8504 (1.348)**	11.6004 (1.392)**	11.6669 (1.422)**	12.5057 (1.446)**	12.6225 (1.465)**
$\bar{C}_5$ = 11.2390	-	-	-	-	-	5.6065 (1.276)**	9.3556 (1.348)**	9.4221 (1.392)**	10.2609 (1.422)**	10.3777 (1.446)**
$\bar{C}_4$ = 5.6334	-	-	-	-	-	-	3.7500 (1.276)**	3.8165 (1.348)**	4.6553 (1.392)**	4.7721 (1.422)**
$\bar{C}_1$ = 1.8834	-	-	-	-	-	-	-	0.0665 (1.036)NS	0.9053 (1.115)NS	1.0221 (1.162)NS
$\bar{C}_9$ = 1.8169	-	-	-	-	-	-	-	-	0.8388 (1.036)NS	0.9556 (1.115)NS
$\bar{C}_8$ = 0.9781	-	-	-	-	-	-	-	-	-	0.1168 (1.036)NS
$\bar{C}_0$ = 0.8613	-	-	-	-	-	-	-	-	-	-

** p < 0.01 * p < 0.05 NS not statistically significant

CONSTANTS: $s = \sqrt{9.212/(6 \times 2) \times 10} = 0.277$

$SR_{0.01} = 5.45$, $SR_{0.05} = 4.65$ (tabled values)
for V = 81 df and n = 10

APPENDIX II

STUDY NO. 2

Tabulations of the Experimental Data and the Statistical Analyses

Table 22: STUDY NO. 2 - Subjective TV scores, corrected for guessing (vide APPENDIX V: pages 426-430), for each of the ten identical runs undertaken at the two sessions (AM and PM).

(Checklist of TV system control settings: APPENDIX XIIIB: page 502).

N = 5 subjects.

Table 22

Subject No: 1

	Run	STIMULUS NO.								
AM	No.	0	1	2	3	4	5	6	7	8	9
	1	0	0	7.33	10.00	6.00	10.00	10.00	10.00	0	0
	2	4.67	2.00	10.00	10.00	6.00	10.00	10.00	10.00	0	0
	3	0	0	10.00	10.00	6.00	10.00	10.00	10.00	0	0
	4	0.67	2.00	10.00	10.00	6.00	8.67	10.00	10.00	0	6.00
	5	2.00	3.33	10.00	10.00	7.33	10.00	10.00	10.00	4.67	0
	6	0	0	10.00	8.67	6.00	10.00	10.00	10.00	6.00	0.67
	7	0.67	0	8.67	8.67	3.33	7.33	10.00	10.00	0.67	0.67
	8	0.67	2.00	8.67	10.00	4.67	8.67	10.00	10.00	0.67	6.00
	9	2.00	0.67	10.00	7.33	2.00	8.67	10.00	10.00	0	4.67
	10	0	2.00	10.00	10.00	6.00	10.00	10.00	10.00	0	2.00
	£	10.67	12.00	94.67	94.67	53.33	93.33	100.00	100.00	12.00	20.00
PM	1	0	6.00	10.00	10.00	7.33	8.67	10.00	10.00	0.67	0.67
	2	0	3.33	10.00	10.00	7.33	10.00	10.00	10.00	0	2.00
	3	0.67	3.33	10.00	10.00	8.67	10.00	10.00	10.00	0	0.67
	4	0	3.33	10.00	10.00	7.33	8.67	10.00	10.00	0.67	3.33
	5	0	0.67	10.00	10.00	0.67	10.00	10.00	10.00	3.33	3.33
	6	0.67	0.67	10.00	10.00	10.00	7.33	10.00	10.00	0	0.67
	7	2.00	3.33	10.00	10.00	2.00	10.00	10.00	10.00	2.00	0
	8	2.00	0.67	10.00	10.00	4.67	6.00	10.00	10.00	0.67	0
	9	0	3.33	10.00	10.00	4.67	10.00	10.00	10.00	0	0
	10	0	0	10.00	10.00	6.00	8.67	10.00	10.00	0	0
	£	5.33	24.67	100.00	100.00	58.67	89.33	100.00	100.00	7.33	10.67

Table 22 (continued)

Subject No: 2

	Run	STIMULUS NO.									
AM	No.	0	1	2	3	4	5	6	7	8	9
	1	0	6.00	10.00	8.67	4.67	6.00	10.00	10.00	0	2.00
	2	0.67	4.67	8.67	10.00	6.00	7.33	10.00	10.00	0	0
	3	2.00	0	8.67	10.00	6.00	6.00	10.00	10.00	0.67	2.00
	4	0.67	0	10.00	10.00	0.67	8.67	10.00	10.00	0.67	0
	5	2.00	0	10.00	10.00	3.33	6.00	10.00	10.00	0.67	2.00
	6	0	2.00	8.67	10.00	2.00	4.67	10.00	10.00	0	3.33
	7	0.67	0	10.00	10.00	4.67	8.67	10.00	10.00	0.67	4.67
	8	0	2.00	8.67	10.00	6.00	10.00	10.00	10.00	0.67	2.00
	9	2.00	3.33	8.67	10.00	4.67	7.33	10.00	10.00	2.00	0.67
	10	3.33	2.00	10.00	10.00	4.67	4.67	10.00	10.00	0	2.00
	£	11.33	20.00	93.33	98.67	42.67	69.33	100.00	100.00	5.33	18.67
PM	1	0	0	10.00	10.00	3.33	8.67	10.00	10.00	0	0.67
	2	0.67	0	10.00	10.00	3.33	8.67	10.00	10.00	3.33	2.00
	3	0	3.33	8.67	10.00	3.33	8.67	10.00	10.00	0	2.00
	4	3.33	0.67	8.67	10.00	4.67	10.00	10.00	10.00	0	0
	5	0	0.67	10.00	10.00	10.00	10.00	10.00	10.00	2.00	0
	6	0	3.33	8.67	10.00	0.67	7.33	10.00	10.00	3.33	0.67
	7	0.67	2.00	8.67	8.67	4.67	10.00	10.00	10.00	0	0.67
	8	2.00	0.67	10.00	10.00	6.00	10.00	10.00	10.00	0	0
	9	0	0	8.67	10.00	0.67	8.67	10.00	10.00	0	2.00
	10	0.67	0	8.67	10.00	3.33	6.00	10.00	10.00	3.33	0
	£	7.33	10.67	90.67	98.67	40.00	88.00	100.00	100.00	12.00	8.00

Table 22 (continued)

Subject No: 3

	Run	STIMULUS NO.								
AM	No.	0	1	2	3	4	5	6	7	8	9
	1	2.00	0.67	7.33	7.33	3.33	6.00	10.00	10.00	2.00	2.00
	2	0.67	0	7.33	10.00	6.00	0.67	10.00	10.00	0	2.00
	3	0	2.00	6.00	10.00	3.33	8.67	10.00	10.00	0.67	2.00
	4	0	0.67	6.00	10.00	0	7.33	10.00	10.00	0.67	2.00
	5	2.00	0	8.67	10.00	0.67	7.33	10.00	10.00	0	0.67
	6	0	0.67	8.67	10.00	0.67	3.33	10.00	10.00	0	2.00
	7	0	2.00	10.00	10.00	3.33	8.67	10.00	10.00	3.33	0
	8	2.00	2.00	6.00	10.00	3.33	3.33	10.00	10.00	2.00	2.00
	9	0	0	8.67	8.67	4.67	6.00	10.00	10.00	0	0
	10	0	3.33	8.67	10.00	0.67	2.00	10.00	10.00	4.67	0
	£.	6.67	11.33	77.33	96.00	26.00	53.33	100.00	100.00	13.33	12.67
PM	1	2.00	0	10.00	10.00	6.00	4.67	10.00	10.00	2.00	0.67
	2	3.33	0	4.67	10.00	0.67	6.00	10.00	10.00	0	0
	3	0.67	2.00	8.67	10.00	0	7.33	10.00	10.00	2.00	2.00
	4	0	3.33	3.33	8.67	0	3.33	10.00	10.00	0.67	2.00
	5	0	3.33	8.67	8.67	0.67	0.67	10.00	10.00	2.00	2.00
	6	0	0.67	2.00	10.00	0.67	2.00	10.00	10.00	0	2.00
	7	2.00	0.67	6.00	8.67	8.67	8.67	10.00	10.00	0	2.00
	8	0	3.33	3.33	10.00	0	6.00	10.00	10.00	2.00	0
	9	0.67	2.00	6.00	7.33	3.33	2.00	10.00	10.00	0	2.00
	10	2.00	2.00	6.00	10.00	0	2.00	10.00	10.00	0	2.00
	£	10.67	17.33	58.67	93.33	12.00	42.67	100.00	100.00	8.67	14.67

Table 22 (continued)

Subject No: 4

	Run	STIMULUS NO.								
AM	No.	0	1	2	3	4	5	6	7	8	9
	1	2.00	0.67	3.33	4.67	3.33	6.00	10.00	10.00	0	0
	2	0.67	2.00	6.00	10.00	0	4.67	10.00	10.00	2.00	0
	3	0	0.67	3.33	8.67	4.67	2.00	10.00	10.00	0	0
	4	2.00	4.67	3.33	8.67	4.67	6.00	10.00	10.00	0	2.00
	5	0	3.33	3.33	10.00	0	4.67	10.00	10.00	0	3.33
	6	3.33	4.67	10.00	10.00	4.67	7.33	10.00	10.00	2.00	0.67
	7	3.33	0	6.00	8.67	0.67	6.00	10.00	10.00	2.00	0.67
	8	0.67	6.00	7.33	10.00	3.33	4.67	10.00	10.00	2.00	2.00
	9	0	0	10.00	10.00	0.67	3.33	10.00	10.00	0	3.33
	10	3.33	0	7.33	10.00	4.67	7.33	10.00	10.00	0.67	4.67
	$\bar{x}$	15.33	22.00	60.00	90.67	26.67	52.00	100.00	100.00	8.67	16.67
PM	1	0	0	10.00	8.67	0	7.33	10.00	10.00	0	0
	2	0	0	7.33	8.67	3.33	4.67	10.00	10.00	0	0
	3	0.67	0	4.67	10.00	0.67	6.00	10.00	10.00	2.00	0
	4	0.67	0.67	8.67	10.00	3.33	4.67	10.00	10.00	3.33	0
	5	0	0	7.33	10.00	2.00	7.33	10.00	10.00	3.33	0
	6	0	3.33	8.67	10.00	6.00	7.33	10.00	10.00	0	2.00
	7	0	0	7.33	10.00	3.33	8.67	10.00	10.00	0	0.67
	8	2.00	3.33	8.67	10.00	4.67	6.00	10.00	10.00	0.67	0
	9	0.67	0.67	8.67	10.00	4.67	6.00	10.00	10.00	0.67	0
	10	0.67	2.00	8.67	10.00	4.67	4.67	10.00	10.00	0	0
	$\bar{x}$	4.67	10.00	80.00	97.33	32.67	62.67	100.00	100.00	10.00	2.67

Table 22 (continued)

Subject No: 5

AM	Run No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
	1	2.00	4.67	10.00	10.00	8.67	10.00	10.00	10.00	0.67	3.33
	2	0.67	6.00	10.00	10.00	7.33	10.00	10.00	10.00	0.67	7.33
	3	0.67	2.00	10.00	8.67	10.00	10.00	10.00	10.00	0.67	2.00
	4	0.67	6.00	10.00	10.00	7.33	8.67	10.00	10.00	3.33	0.67
	5	2.00	7.33	10.00	8.67	7.33	10.00	10.00	10.00	0	7.33
	6	0.67	7.33	10.00	10.00	6.00	10.00	10.00	10.00	4.67	6.00
	7	0.67	7.33	10.00	10.00	10.00	10.00	10.00	10.00	0.67	2.00
	8	0	6.00	10.00	10.00	8.67	10.00	10.00	10.00	2.00	2.00
	9	0.67	2.00	10.00	10.00	8.67	10.00	10.00	10.00	2.00	2.00
	10	0.67	4.67	10.00	10.00	7.33	10.00	10.00	10.00	0	6.00
	£	8.67	53.33	100.00	97.33	81.33	98.67	100.00	100.00	14.67	38.67
PM	1	0	3.33	10.00	10.00	10.00	10.00	10.00	10.00	0.67	0.67
	2	0.67	3.33	10.00	10.00	6.00	8.67	10.00	10.00	0	4.67
	3	0.67	4.67	10.00	10.00	10.00	8.67	10.00	10.00	0.67	0
	4	2.00	2.00	10.00	10.00	4.67	10.00	10.00	10.00	2.00	2.00
	5	2.00	4.67	10.00	10.00	6.00	10.00	10.00	10.00	0.67	6.00
	6	0	3.33	10.00	10.00	8.67	7.33	10.00	10.00	0	6.00
	7	0	6.00	10.00	10.00	7.33	10.00	10.00	10.00	2.00	3.33
	8	0.67	0.67	8.67	10.00	6.00	10.00	10.00	10.00	0	2.00
	9	0	0	10.00	10.00	8.67	8.67	10.00	10.00	0	6.00
	10	0	2.00	10.00	10.00	6.00	8.67	10.00	10.00	2.00	3.33
	£	6.00	30.00	98.67	100.00	73.33	92.00	100.00	100.00	8.00	34.00

Table 23 : STUDY NO. 2 - Repeatability of subject scoring: subjective TV scores, corrected for guessing (vide APPENDIX V, pages 426-430), summed over the ten identical runs undertaken at the two sessions (AM and PM).

(Refer to the data presented in Table 22: pages 274-279 ; also refer to Table 12: page 171 for the Pearson product-moment correlation coefficients calculated from this data using a programmable desk top calculator).

N = 5 subjects : individuals and group - uniform acuity level.

Table 23

Stimulus No. In Cycle.	SUBJECT NO. 1 AM	1 PM	2 AM	2 PM	3 AM	3 PM	4 AM	4 PM	5 AM	5 PM	Group (N = 5) AM	Group (N = 5) PM
0	10.67	5.33	11.33	7.33	6.67	10.67	15.33	4.67	8.67	6.00	52.67	34.00
8	12.00	7.33	5.33	12.00	13.33	8.67	8.67	10.00	14.67	8.00	54.00	54.67
1	12.00	24.67	20.00	10.67	11.33	17.33	22.00	10.00	53.33	30.00	118.67	92.67
9	20.00	10.67	18.67	8.00	12.67	14.66	16.67	2.67	38.67	34.00	106.67	70.00
4	53.33	58.67	42.67	40.00	26.00	12.00	26.67	32.67	81.33	73.33	230.00	216.67
5	93.33	89.33	69.33	88.00	53.33	42.67	52.00	62.67	98.67	92.00	366.67	374.67
2	94.67	100.00	93.33	90.67	77.33	58.67	60.00	80.00	100.00	98.67	425.33	428.00
3	94.67	100.00	98.67	98.67	96.00	93.33	90.67	97.33	97.33	100.00	477.33	489.33
6	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	500.00	500.00
7	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	500.00	500.00

Table 24: STUDY No. 2 - Reliability of subject scoring:

(Refer to Table 13: page 172 for summary of results).

Student t-test for correlated samples (non-directional) : full calculations relating to the data of subject No. 1 are presented, to illustrate this statistical procedure (vide APPENDIX VIIA : page 454).

Table 24

Subject No. 1:	Summed (corrected) results over ten runs at two sessions (am & pm)			
Stimulus No.	AM X1	PM X2	DIFFERENCE D	D^2
0	10.67	5.33	5.34	28.52
8	12.00	7.33	4.67	21.81
1	12.00	24.67	-12.67	160.53
9	20.00	10.67	9.33	87.05
4	53.33	58.67	-5.34	28.52
5	93.33	89.33	4.00	16.00
2	94.67	100.00	-5.33	28.41
3	94.67	100.00	-5.33	28.41
6	100.00	100.00	0	0
7	100.00	100.00	0	0
Σ	590.67	596.00	-5.33	399.25

Null hypothesis (H_o): μ am = μ pm

Alternative hypothesis (H_1) μ am < μ pm (learning ?)

μ am > μ pm (fatigue ?)

Critical region: df = 9, $t_{0.05} \geq +$ 2.262 and $\leq -$ 2.262

The sum of squares of the difference scores:

$$\Sigma d^2 = \Sigma D^2 - (\Sigma D)^2/n = 399.25 - (-5.33)^2/10$$
$$= 396.41$$

The standard error of the mean difference:

$$S_{\bar{D}} = \sqrt{\Sigma d^2/n\,(n-1)} = \sqrt{396.41/10\,(9)}$$
$$= 2.10$$

The mean difference:

$$\bar{D} = -5.33/10 = -0.53$$

Whence $t = \bar{D}/S_{\bar{D}} = -0.53/2.10 = -0.252$

Conclusion: Since the obtained t does not fall within the critical region, accept H_o.

APPENDIX III

STUDY NO. 3

Tabulations of the Experimental Data and the Statistical Analyses

Table 25: STUDY NO. 3 - Subjective TV scores, corrected for guessing (vide APPENDIX V , pages 426-430), summed over five identical runs at each of twelve experimental sessions.

(Checklist of TV system control settings : APPENDIX XIIIC, page 503).

N = 5 subjects.

Table 25

SUBJECT No. 1		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
SPECS		4.67	8.00	17.33	32.67	2.67	12.67	50.00	50.00	0	6.67
SOFT LENS VISIT	I	10.00	4.00	23.33	40.67	6.67	23.33	50.00	50.00	6.00	3.33
	II	8.67	6.00	47.33	50.00	13.33	35.33	50.00	50.00	8.00	13.33
EYE MOVEMENT TO FIXATION	1	1.33	2.67	23.33	38.00	4.67	10.00	50.00	50.00	3.33	8.67
	2	5.33	2.00	22.00	38.00	8.00	15.33	50.00	50.00	5.33	0
	3	8.67	13.33	14.00	26.00	11.33	9.33	50.00	50.00	2.67	2.00
	4	4.67	2.67	27.33	42.00	9.33	22.00	50.00	50.00	6.00	4.00
	5	10.67	11.33	27.33	47.33	5.33	27.33	50.00	50.00	1.33	6.00
	6	4.67	11.33	27.33	40.67	5.33	17.33	50.00	50.00	5.33	2.67
	7	7.33	4.00	23.33	42.00	12.67	14.67	50.00	50.00	4.00	2.67
	8	4.00	4.00	23.33	42.00	10.67	14.67	50.00	50.00	0.67	4.00
4 - Pt		11.33	6.67	44.67	46.00	7.33	27.33	50.00	50.00	2.67	12.00

SUBJECT NO. 2		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
SPECS		15.33	18.67	48.67	48.67	26.00	47.33	50.00	50.00	8.00	9.33
SOFT LENS VISIT	I	2.67	4.67	38.67	50.00	28.67	46.00	50.00	50.00	8.00	7.33
	II	19.33	18.67	50.00	50.00	28.67	47.33	50.00	50.00	6.67	16.00
EYE MOVEMENT TO FIXATION	1	6.67	16.67	48.67	50.00	12.67	44.67	50.00	50.00	3.33	8.67
	2	6.00	15.33	46.00	50.00	20.67	39.33	50.00	50.00	2.67	10.00
	3	4.67	6.67	48.67	48.67	16.67	39.33	50.00	50.00	10.67	13.33
	4	9.33	16.00	50.00	50.00	24.67	48.67	50.00	50.00	8.67	6.00
	5	11.33	12.67	48.67	50.00	20.67	42.00	50.00	50.00	3.33	4.00
	6	8.67	10.67	50.00	48.67	28.67	38.00	50.00	50.00	7.33	15.33
	7	10.67	11.33	50.00	50.00	32.67	43.33	50.00	50.00	3.33	6.67
	8	4.00	16.00	50.00	50.00	27.33	44.67	50.00	50.00	5.33	6.00
4 - Pt		4.67	8.00	48.67	48.67	24.00	43.33	50.00	50.00	4.67	10.00

Table 25 (continued)

SUBJECT No. 3		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
SPECS		2.67	4.00	50.00	48.67	18.67	46.00	50.00	50.00	4.00	10.00
SOFT LENS VISIT	I	6.67	6.67	39.33	50.00	18.00	34.00	50.00	50.00	8.00	15.33
	II	6.00	8.67	42.00	46.00	26.00	40.67	50.00	50.00	9.33	12.67
EYE MOVEMENT TO FIXATION	1	6.00	4.67	46.00	50.00	16.00	35.33	50.00	50.00	6.67	14.00
	2	4.00	10.00	36.67	46.00	6.00	31.33	50.00	50.00	1.33	9.33
	3	0.67	5.33	34.00	46.00	8.00	39.33	50.00	50.00	6.00	6.67
	4	3.33	2.00	48.67	47.33	19.33	40.67	50.00	50.00	2.67	0
	5	6.00	2.67	34.00	48.67	10.00	25.33	50.00	50.00	4.00	5.33
	6	7.33	10.00	28.67	42.00	11.33	42.00	50.00	50.00	7.33	1.33
	7	4.67	15.33	35.33	48.67	22.00	30.00	50.00	50.00	6.67	8.00
	8	5.33	0.67	39.33	43.33	12.00	30.00	50.00	50.00	4.00	3.33
4 - Pt		6.00	0.67	43.33	50.00	15.33	39.33	50.00	50.00	4.67	6.67

SUBJECT No. 4		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
SPECS		9.33	7.33	48.67	50.00	26.00	47.33	50.00	50.00	5.33	15.33
SOFT LENS VISIT	I	2.67	8.67	47.33	48.67	11.33	36.67	50.00	50.00	3.33	8.00
	II	12.00	7.33	43.33	47.33	8.67	40.67	50.00	50.00	1.33	7.33
EYE MOVEMENT TO FIXATION	1	4.00	10.00	48.67	50.00	13.33	38.00	50.00	50.00	2.67	8.67
	2	11.33	7.33	44.67	50.00	12.67	36.67	50.00	50.00	4.00	12.00
	3	10.00	9.33	48.67	50.00	8.67	38.00	50.00	50.00	3.33	7.33
	4	10.67	14.00	47.33	50.00	6.00	40.67	50.00	50.00	6.00	8.00
	5	10.00	4.67	50.00	48.67	18.00	34.00	50.00	50.00	6.00	7.33
	6	2.67	8.00	48.67	48.67	10.67	35.33	50.00	50.00	4.00	8.67
	7	2.00	6.67	50.00	50.00	19.33	35.33	50.00	50.00	4.67	11.33
	8	13.33	19.33	46.00	50.00	14.00	46.00	50.00	50.00	4.67	14.00
4 - Pt		4.00	2.00	47.33	48.67	14.67	38.00	50.00	50.00	2.67	10.00

Table 25 (continued)

SUBJECT No. 5		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
SPECS		5.33	12.67	44.67	48.67	11.33	34.00	50.00	50.00	6.67	8.00
SOFT LENS VISIT	I	6.67	10.00	43.33	50.00	15.33	30.00	50.00	50.00	1.33	10.00
	II	4.00	8.00	47.33	48.67	18.00	42.00	50.00	50.00	5.33	4.67
EYE MOVEMENT TO FIXATION	1	8.67	1.33	48.67	48.67	26.00	36.67	50.00	50.00	7.33	12.00
	2	2.67	11.33	44.67	50.00	22.00	31.33	50.00	50.00	6.67	7.33
	3	3.33	4.67	50.00	50.00	30.00	47.33	50.00	50.00	7.33	17.33
	4	1.33	1.33	46.00	48.67	13.33	39.33	50.00	50.00	6.67	10.67
	5	6.67	6.00	48.67	50.00	19.33	38.00	50.00	50.00	4.00	10.67
	6	10.67	8.67	50.00	48.67	24.67	42.00	50.00	50.00	4.67	9.33
	7	6.67	6.00	50.00	50.00	16.67	39.33	50.00	50.00	4.00	7.33
	8	3.33	4.67	50.00	50.00	18.00	38.00	50.00	50.00	6.00	6.67
4 - Pt		4.67	10.67	50.00	50.00	28.67	44.67	50.00	50.00	2.00	8.67

Table 26: STUDY NO. 3 - Summary table, two-way analysis of variance (completely crossed design).

(Refer to TABLE 15A: page 179, and APPENDIX VIA: pages 432-434).

Table 26A: All subjects (N = 5) over all twelve experimental sessions - uniform acuity level.

Table 26B: All subjects (N = 5) over nine (eight direct and one multiple) eye movement sessions only - uniform acuity level.

Table 26A: All Subjects (N = 5) over all twelve experimental sessions - uniform acuity level.

SOURCE OF VARIATION			SUM SQUARES	df	MEAN SQUARE	F*
	A	Experimental Session	426.3021	11	38.7547	1.0513
Error	(AS)		1622.0459	44	36.8647	
	B	Level of Stimulus Angular Subtense	208724.6949	9	23191.6328	126.4471
Error	(BS)		6602.7533	36	183.4098	
	AB		1215.6272	99	12.2791	0.9505
Error	(ABS)		5115.8018	396	12.9187	
	-	Subjects	5062.3349	4	1265.5837	
		TOTAL	228769.5601	599		

* F-ratios: refer to Table 15A: page 179.

Table 26B: All Subjects (N = 5) over nine (eight direct and one multiple) eye movement sessions only - uniform acuity level.

SOURCE OF VARIANCE			SUM SQUARES	df	MEAN SQUARE	F*
	A	Experimental Session	118.0685	8	14.7586	0.5810
Error	(AS)		812.8688	32	25.4021	
	B	Level of Stimulus Angular Subtense	158409.6597	9	17601.0733	112.4234
Error	(BS)		5636.1815	36	156.5606	
	AB		907.7106	72	12.6071	1.0952
Error	(ABS)		3315.2619	288	11.5113	
	-	Subjects	4134.6284	4	1033.6571	
		TOTAL	173334.3794	449		

* F-ratios: refer to Table 15A: page 179.

Table 27 : STUDY NO. 3 - Summary table, two-way analysis of variance (longhand calculation).

(Refer to TABLE 15B: page 180).

All subjects (N = 5) over three stationary experimental sessions only - uniform acuity level.

Table 27: All Subjects (N = 5) over three stationary experimental sessions only - uniform acuity level.

SOURCE OF VARIATION		SUM SQUARES	df	MEAN SQUARE	F†
Between - Groups		50825.1931	29		
A	Experimental Session	202.3193	2	101.1597	2.6951
B	Level of Stimulus Angular Subtense	50414.8831	9	5601.6537	149.2393
AB		207.9907	18	11.5550	0.3078
Within - Groups (Error)		4504.1580	120	37.5347	
	TOTAL	55329.3511	149		

† F-ratios: refer to Table 15B: page 180.

Table 28: STUDY NO. 3 - Summary table, Tukey's analysis: Differences among means and levels of statistical significance.

(Refer to TABLE 15A,B: pages179, 180, and TABLES 26, 27: pages 288-292, inclusive).

Table 28A: Factor B: Level of Stimulus Angular Subtense.

All subjects (N = 5) over all twelve experimental sessions - uniform acuity level.

Table 28B: Factor B: Level of Stimulus Angular Subtense.

All subjects (N = 5) over nine eye movement sessions only - uniform acuity level.

Table 28C: Factor B: Level of Stimulus Angular Subtense.

All subjects (N = 5) over three stationary sessions only - uniform acuity level.

For each pairwise comparison between means in Tables 28A-28C, the data are listed in a uniform sequence: the actual difference between the means, the calculated "wholly significant difference" (WSD) and an indication of the relevant statistical significance level.

Table 28A: Factor B : Level of Stimulus Angular Subtense
All subjects (N = 5) over all twelve experimental sessions - uniform acuity level.

	$\bar{B}_7$	$\bar{B}_6$	$\bar{B}_3$	$\bar{B}_2$	$\bar{B}_5$	$\bar{B}_4$	$\bar{B}_9$	$\bar{B}_1$	$\bar{B}_0$	$\bar{B}_8$
$\bar{B}_7$ = 50.0000	-	0 (6.642)NS	2.7992 (7.149)NS	8.0000 (7.464)*	14.7228 (9.212)**	33.6997 (9.369)**	41.6447 (9.509)**	41.7995 (9.614)**	43.3440 (9.701)**	45.1333 (9.789)**
$\bar{B}_6$ = 50.0000	-	-	2.7992 (6.642)NS	8.0000 (7.149)*	14.7228 (9.002)**	33.6997 (9.212)**	41.6447 (9.369)**	41.7995 (9.509)**	43.3440 (9.614)**	45.1333 (9.701)**
$\bar{B}_3$ = 47.2008	-	-	-	5.2008 (6.642)NS	11.9236 (8.723)**	30.9005 (9.002)**	38.8455 (9.212)**	39.0003 (9.369)**	40.5448 (9.509)**	42.3341 (9.614)**
$\bar{B}_2$ = 42.0000	-	-	-	-	6.7228 (6.642)*	25.6997 (8.723)**	33.6447 (9.002)**	33.7995 (9.212)**	35.3440 (9.369)**	37.1333 (9.509)**
$\bar{B}_5$ = 35.2772	-	-	-	-	-	18.9769 (8.233)**	26.9219 (8.723)**	27.0767 (9.002)**	28.6212 (9.212)**	30.4105 (9.369)**
$\bar{B}_4$ = 16.3003	-	-	-	-	-	-	7.9450 (6.642)*	8.0998 (7.149)*	9.6443 (9.002)**	11.4336 (9.212)**
$\bar{B}_9$ = 8.3553	-	-	-	-	-	-	-	0.1548 (6.642)NS	1.6993 (7.149)NS	3.4886 (7.464)NS
$\bar{B}_1$ = 8.2005	-	-	-	-	-	-	-	-	1.5445 (6.642)NS	3.3338 (7.149)NS
$\bar{B}_0$ = 6.6560	-	-	-	-	-	-	-	-	-	1.7893 (6.642)NS
$\bar{B}_8$ = 4.8667	-	-	-	-	-	-	-	-	-	-

** P < 0.01 * p < 0.05 NS not statistically significant

CONSTANTS: $s = \sqrt{183.410/\ 12\ X\ 5} = 1.748$

$SR_{0.01} = 5.60$, $SR_{0.05} = 4.74$ (tabled values)

for V = 36 df and n = 10

Table 28B: Factor B : Level of Stimulus Angular Subtense
All subjects (N = 5) over nine eye movement sessions only - uniform acuity level.

	$\bar{B}_7$	$\bar{B}_6$	$\bar{B}_3$	$\bar{B}_2$	$\bar{B}_5$	$\bar{B}_4$	$\bar{B}_1$	$\bar{B}_9$	$\bar{B}_0$	$\bar{B}_8$
$\bar{B}_7$ = 50.0000	-	0 (7.087)NS	2.8438 (7.628)NS	8.0293 (7.954)*	15.4822 (9.819)**	34.0293 (9.987)**	42.0293 (10.136)**	42.1333 (10.248)**	43.7033 (10.351)**	45.3182 (10.444)**
$\bar{B}_6$ = 50.0000	-	-	2.8438 (7.087)NS	8.0293 (7.628)*	15.4822 (9.605)**	34.0293 (9.819)**	42.0293 (9.987)**	42.1333 (10.136)**	43.7033 (10.248)**	45.3182 (10.351)**
$\bar{B}_3$ = 47.1562	-	-	-	5.1855 (7.087)NS	12.6384 (9.297)**	31.1855 (9.605)**	39.1855 (9.819)**	39.2895 (9.987)**	40.8595 (10.136)**	42.4744 (10.248)**
$\bar{B}_2$ = 41.9707	-	-	-	-	7.4529 (7.087)*	26.0000 (9.297)**	34.0000 (9.605)**	34.1040 (9.819)**	35.6740 (9.987)**	37.2889 (10.136)**
$\bar{B}_5$ = 34.5178	-	-	-	-	-	18.5471 (8.784)**	26.5471 (9.297)**	26.6511 (9.605)**	28.2211 (9.819)**	29.8360 (9.987)**
$\bar{B}_4$ = 15.9707	-	-	-	-	-	-	8.0000 (7.087)*	8.1040 (7.628)*	9.6740 (9.605)**	11.2889 (9.819)**
$\bar{B}_1$ = 7.9707	-	-	-	-	-	-	-	0.1040 (7.087)NS	1.6740 (7.628)NS	3.2889 (7.954)NS
$\bar{B}_9$ = 7.8667	-	-	-	-	-	-	-	-	1.5700 (7.087)NS	3.1849 (7.628)NS
$\bar{B}_0$ = 6.2967	-	-	-	-	-	-	-	-	-	1.6149 (7.087)NS
$\bar{B}_8$ = 4.6818	-	-	-	-	-	-	-	-	-	-

** $p < 0.01$ * $p < 0.05$ NS not statistically significant

CONSTANTS: $s = \sqrt{156.561 / 9 \times 5} = 1.865$

$SR_{0.01} = 5.60$, $SR_{0.05} = 4.74$ (tabled values)

for V = 36 df and n = 10

Table 28C: Factor B : Level of Stimulus Angular Subtense
All subjects (N = 5) over three stationary sessions only - uniform acuity level.

	$\overline{B}_7$	$\overline{B}_6$	$\overline{B}_3$	$\overline{B}_2$	$\overline{B}_5$	$\overline{B}_4$	$\overline{B}_9$	$\overline{B}_1$	$\overline{B}_0$	$\overline{B}_8$
$\overline{B}_7$ = 50.0000	-	0 (6.011)NS	2.6653 (6.470)NS	7.9120 (6.755)*	12.4447 (8.337)**	32.7107 (8.479)**	40.1787 (8.606)**	41.1100 (8.701)**	42.2660 (8.780)**	44.5787 (8.859)**
$\overline{B}_6$ = 50.0000	-	-	2.6653 (6.011)NS	7.9120 (7.894)**	12.4447 (8.147)**	32.7107 (8.337)**	40.1787 (8.479)**	41.1100 (8.606)**	42.2660 (8.701)**	44.5787 (8.780)**
$\overline{B}_3$ = 47.3347	-	-	-	5.2467 (6.011)NS	9.7794 (7.894)**	30.0454 (8.147)**	37.5134 (8.337)**	38.4447 (8.479)**	39.6007 (8.606)**	41.9134 (8.701)**
$\overline{B}_2$ = 42.0880	-	-	-	-	4.5327 (6.011)NS	24.7987 (7.894)**	32.2667 (8.147)**	33.1980 (8.337)**	34.3540 (8.479)**	36.6667 (8.606)**
$\overline{B}_5$ = 37.5553	-	-	-	-	-	20.2660 (7.451)**	27.7340 (7.894)**	28.6653 (8.147)**	29.8213 (8.337)**	32.1340 (8.479)**
$\overline{B}_4$ = 17.2893	-	-	-	-	-	-	7.4680 (7.451)**	8.3993 (7.894)**	9.5553 (8.147)**	11.8680 (8.337)**
$\overline{B}_9$ = 9.8213	-	-	-	-	-	-	-	0.9313 (6.011)NS	2.0873 (6.470)NS	4.4000 (6.755)NS
$\overline{B}_1$ = 8.8900	-	-	-	-	-	-	-	-	1.1560 (6.011)NS	3.4687 (6.470)NS
$\overline{B}_0$ = 7.7340	-	-	-	-	-	-	-	-	-	2.3127 (6.011)NS
$\overline{B}_8$ = 5.4213	-	-	-	-	-	-	-	-	-	-

** $p < 0.01$ * $p < 0.05$ NS not statistically significant

CONSTANTS: $s = \sqrt{35.5347/ 3 \times 5} = 1.5819$

$SR_{0.01} = 5.60$, $SR_{0.05} = 4.74$ (tabled values)

for V = 36 df and n = 10

Table 29: The results of an investigation of the uniformity of TV stimulus presentation and interval times (refer to Section 7.4Ai, pages 185-186).

The specific control settings selected for this investigation were those used for all work with the TV system from STUDY NO. 3 onwards, viz:

PRESENTATION - control setting 2 : 2.92s

INTERVAL - control setting 3 : 2.65s

(Table 5 : page 105).

Table 29A,B The results of an investigation of presentation and interval times over the duration of a typical ($3\frac{1}{2}$ hour) experimental session, sampling commencing 30, 90, 150 and 210 minutes after the TV system was switched on, and on three separate occasions.

Table 29C,D The results of an investigation of presentation and interval times over the duration of a fourteen week period, sampling at the beginning of weeks number 1, 7 and 14, and at 30, 90, 150 and 210 minutes after the TV system was switched on.

These results demonstrate no statistically significant variation in the chosen presentation and interval times under the specific conditions of operation of the TV system (vide Section 7.4Ai, pages 185-186).

Table 29A: The results of an investigation of presentation times over the duration of an experimental session.

PRESENTATION TIMES (s)												
..... minutes after TV on												
30			90			150			210			
I	II	III	I	II	III	I	II	III	I	II	III	
2.9	2.9	3.0	3.0	2.8	3.0	3.0	2.9	3.0	3.0	3.1	2.9	
3.1 3.1	3.0 3.0	2.9 2.9	3.0 3.1	2.9 3.0	3.1 3.1	3.1 3.0	2.9 3.0	3.1 2.9	3.0 2.9	3.0 3.0	3.0 2.8	
2.9 3.0	2.9 3.0	3.0 3.1	2.9 2.8	2.8 3.1	2.9 3.0	3.0 3.1	2.9 3.0	3.1 2.9	3.0 3.0	3.0 2.9	2.9 2.9	
3.0 2.9	3.1 2.9	3.0 3.1	3.0 3.1	3.0 2.9	3.1 3.0	2.9 3.0	2.9 3.0	2.9 3.0	3.0 2.9	3.1 2.9	3.0 2.8	
3.0 3.0	3.1 3.0	3.1 2.9	2.8 3.1	3.0 2.8	3.1 2.8	2.9 3.0	3.0 2.9	3.0 3.1	2.9 3.1	3.0 3.0	3.0 3.0	
3.0 3.1	3.0 3.1	3.0 3.0	3.0 2.8	3.0 2.9	3.0 3.0	2.9 2.8	3.0 3.0	3.0 2.8	2.9 2.9	3.0 3.1	3.1 2.9	
3.1 2.9	2.9 3.0	2.9 3.1	3.0 3.1	3.1 3.1	3.0 2.9	2.9 3.0	2.9 3.0	3.0 3.0	3.0 2.9	3.0 3.0	2.9 3.0	
2.8 2.9	2.9 2.9	3.0 3.0	3.1 3.0	2.9 3.1	2.8 3.0	3.0 3.0	2.9 3.0	2.8 2.9	3.0 3.0	3.0 2.9	3.0 3.0	
3.1 3.0	3.1 2.8	2.9 3.1	2.9 3.1	3.0 3.0	3.1 3.0	3.1 2.8	3.0 2.9	3.1 2.9	3.0 3.1	3.0 3.1	3.0 3.0	
2.9 3.0	3.0 3.1	3.0 2.9	2.9 3.1	3.1 3.0	3.0 3.1	3.0 3.0	2.9 3.0	3.0 2.9	3.0 3.0	3.0 2.9	2.9 2.9	
3.0	3.1	3.0	3.0	2.9	2.9	3.0	2.9	2.9	3.1	3.0	3.0	

SUMMARY TABLE (one-way analysis of variance)

SOURCE	SUM SQUARES	df	MEAN SQUARES	F*
Between Groups	0.001	3	0.000333	0.888
Within Groups	0.003	8	0.000375	
Total	0.004	11		

F*-ratio: Result not statistically significant (tabled values, 3/8 df: $F_{0.01} = 7.59$, $F_{0.05} = 4.07$).

Table 29B: The results of an investigation of interval times over the duration of an experimental session.

INTERVAL TIMES (s)																				
..... minutes after TV on																				
30						90						150						210		
I		II		III		I		II		III		I		II		III		I		II		III	
2.7	2.5	2.7	2.6	2.7	2.6	2.6	2.7	2.5	2.7	2.5	2.7	2.6	2.7	2.7	2.6	2.7	2.7	2.8	2.6	2.5	2.6	2.7	2.6
2.6	2.7	2.7	2.6	2.5	2.6	2.7	2.6	2.6	2.5	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.4	2.7	2.6	2.6	2.5	2.7	2.6
2.7	2.5	2.7	2.7	2.6	2.6	2.6	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.5	2.6	2.6	2.6	2.6	2.6	2.7	2.5	2.6	2.6
2.7	2.8	2.5	2.5	2.6	2.7	2.6	2.8	2.6	2.7	2.7	2.7	2.7	2.5	2.6	2.6	2.7	2.7	2.6	2.7	2.6	2.7	2.5	2.7
2.7	2.6	2.6	2.7	2.6	2.6	2.6	2.6	2.6	2.5	2.6	2.7	2.6	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.7	2.7	2.6	2.6
2.6	2.6	2.6	2.6	2.7	2.6	2.6	2.6	2.7	2.7	2.5	2.7	2.6	2.6	2.6	2.7	2.6	2.5	2.7	2.7	2.5	2.6	2.6	2.6
2.5	2.6	2.7	2.5	2.6	2.7	2.7	2.7	2.6	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.7	2.6	2.5	2.5	2.6	2.6	2.7	2.6
2.6	2.5	2.6	2.5	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.6	2.6	2.7	2.6	2.6	2.7	2.6	2.6	2.7	2.7	2.7	2.6	2.6
2.6	2.6	2.6	2.6	2.5	2.6	2.6	2.5	2.5	2.6	2.7	2.6	2.6	2.5	2.5	2.6	2.6	2.6	2.6	2.6	2.7	2.6	2.6	2.7
2.7	2.5	2.8	2.6	2.7	2.6	2.6	2.6	2.5	2.6	2.7	2.6	2.6	2.6	2.6	2.7	2.6	2.5	2.6	2.5	2.6	2.6	2.6	2.6

SUMMARY TABLE (one-way analysis of variance)

SOURCE	SUM SQUARES	df	MEAN SQUARES	F*
Between Groups	0.001	3	0.000333	-1.332
Within Groups	-0.002	8	-0.000250	
Total	-0.001	11		

F*-ratio: Result not statistically significant (tabled values, 3/8 df: $F_{0.01} = 7.59$, $F_{0.05} = 4.07$).

Table 29C: The results of an investigation of presentation times over the duration of a fourteen week period.

PRESENTATION TIMES (s)																				
SESSION																				
I								II								III				
30		90		150		210		30		90		150		210		30		90		150		210	
2.9	3.1	3.0	3.1	3.0	3.0	3.0	2.9	2.9	3.0	2.8	3.0	2.9	3.0	3.1	3.0	3.0	2.9	3.0	3.1	3.0	2.9	2.9	2.8
3.1	3.0	3.0	2.8	3.1	3.1	3.0	3.0	3.0	3.0	2.9	3.1	2.9	3.0	3.0	2.9	2.9	3.1	3.1	3.0	3.1	2.9	3.0	2.9
2.9	2.9	2.9	3.1	3.0	3.0	3.0	2.9	2.9	2.9	2.8	2.9	2.9	3.0	3.0	2.9	3.0	3.1	2.9	3.0	3.1	3.0	2.9	2.8
3.0	3.0	3.0	3.1	2.9	3.0	2.9	3.1	3.1	3.0	3.0	2.8	2.9	2.9	3.1	3.0	3.0	2.9	3.1	2.8	2.9	3.1	3.0	3.0
3.0	3.1	2.8	2.8	2.9	2.8	2.9	2.9	3.1	3.1	3.0	2.9	3.0	3.0	3.0	3.1	3.1	3.0	3.1	3.0	3.0	2.8	3.0	2.9
3.0	2.9	3.0	3.1	2.9	3.0	3.0	2.9	3.0	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0	3.1	3.0	2.9	3.0	3.0	3.1	3.0
3.1	2.9	3.0	3.0	2.9	3.0	3.0	3.0	2.9	2.9	3.1	3.1	2.9	3.0	3.0	2.9	2.9	3.0	3.0	3.0	3.0	2.9	2.9	3.0
2.8	3.0	3.1	3.1	3.0	2.8	3.0	3.1	2.9	2.8	2.9	3.0	2.9	2.9	3.0	3.1	3.0	3.1	2.8	3.0	2.8	2.9	3.0	3.0
3.1	3.0	2.9	3.1	3.1	3.0	3.0	3.0	3.1	3.1	3.0	3.0	3.0	3.0	3.0	2.9	2.9	2.9	3.1	3.1	3.0	2.9	3.0	2.9
2.9	3.0	2.9	3.0	3.0	3.0	3.0	3.1	3.0	3.1	3.1	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.0	2.9	3.0	2.9	2.9	3.0

SUMMARY TABLE (one-way analysis of variance)

SOURCE	SUM SQUARES	df	MEAN SQUARES	F*
Between Groups	0	2	0	0
Within Groups	0.004	9	0.000444	
Total	0.004	11		

*F-ratio: Result not statistically significant (tabled values, 2/9 df: $F_{0.01} = 8.02$, $F_{0.05} = 4.26$).

Table 29D: The results of an investigation of interval times over the duration of a fourteen week period.

INTERVAL TIMES (s)																								
SESSION																								
I								II								III							
30		90		150		210		30		90		150		210		30		90		150		210		
2.7	2.5	2.6	2.7	2.6	2.7	2.8	2.6	2.7	2.6	2.5	2.7	2.7	2.6	2.5	2.6	2.7	2.6	2.5	2.7	2.7	2.7	2.7	2.6
2.6	2.7	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.6	2.6	2.5	2.6	2.6	2.6	2.5	2.5	2.6	2.6	2.6	2.6	2.4	2.7	2.6
2.7	2.5	2.6	2.7	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.6	2.5	2.6	2.7	2.5	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
2.7	2.8	2.6	2.8	2.7	2.5	2.6	2.7	2.5	2.5	2.6	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.7	2.7	2.7	2.7	2.5	2.7
2.7	2.6	2.6	2.6	2.6	2.7	2.6	2.7	2.6	2.7	2.6	2.5	2.6	2.6	2.7	2.7	2.6	2.6	2.6	2.7	2.6	2.7	2.6	2.6
2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.6	2.6	2.7	2.7	2.6	2.7	2.5	2.6	2.7	2.6	2.5	2.7	2.6	2.5	2.6	2.6
2.5	2.6	2.7	2.7	2.6	2.7	2.5	2.5	2.7	2.5	2.6	2.7	2.6	2.7	2.6	2.6	2.6	2.7	2.6	2.6	2.7	2.6	2.7	2.6
2.6	2.5	2.6	2.6	2.6	2.7	2.6	2.7	2.6	2.5	2.7	2.6	2.6	2.6	2.7	2.7	2.7	2.6	2.7	2.6	2.7	2.6	2.6	2.6
2.6	2.6	2.6	2.5	2.6	2.5	2.6	2.6	2.6	2.6	2.5	2.6	2.5	2.6	2.7	2.6	2.5	2.6	2.7	2.6	2.6	2.6	2.6	2.7
2.7	2.5	2.6	2.6	2.6	2.6	2.6	2.5	2.8	2.6	2.5	2.6	2.6	2.7	2.6	2.6	2.7	2.6	2.7	2.6	2.6	2.5	2.6	2.6

SUMMARY TABLE (one-way analysis of variance)

SOURCE	SUM SQUARES	df	MEAN SQUARES	F*
Between Groups	0.001	2	0.000500	-2.252
Within Groups	-0.002	9	-0.000222	
Total	-0.001	11		

*F-ratio: Result not statistically significant (tabled values, 2/9 df : $F_{0.01} = 8.02$, $F_{0.05} = 4.26$).

Table 30 : The results of an investigation into the existence of a bias in association with the presentation of the TV stimuli (refer to Section 7.4Av, pages 190 - 192).

Table 30A: The number and orientation of individual stimulus presentations to each of five subjects over five runs comprising one hundred stimuli per run. (Two data-sets are presented: I, II).

Table 30B: Summary tables, one-way analysis of variance and Tukey's multiple comparison of means. Analysis undertaken on stimulus presentation data summed over the ten levels of stimulus angular subtense.

Table 30C: Summary tables, two-way analysis of variance and Tukey's multiple comparison of means. Analysis undertaken on individual stimulus presentation data.

Table 30D: Summary table, one-way analysis of variance. Analysis undertaken on individual stimulus presentation data under the break up condition only.

From the two sets of data (TABLE 30AI,II) randomly selected from the results of Study No. 3, there is shown to exist a bias in the TV system towards the presentation of stimuli in the break up configuration (TABLE 30BI,II). This machine bias is shown not to be associated with any particular level of stimulus angular subtense (TABLE 30CI,II) but to be entirely random within this specific orientation TABLE 30DI,II). It will be appreciated that the two data-sets produce similar statistical conclusions (vide Section 7.4Av, pages 190 - 192).

Table 30A(I): The number and orientation[‡] of individual stimulus presentation to each of five subjects over five runs comprising 100 stimuli per run.

SUBJECT NO.		STIMULUS NO. 0	8	1	9	4	5	2	3	6	7	: £.°
1	UP	17	19	29	27	20	22	16	16	20	22	208
	DN	6	3	4	0	3	0	7	6	1	8	38
	L	17	14	10	12	12	19	18	15	17	9	143
	R	10	14	7	11	15	9	9	13	12	11	111
2	UP	45	47	41	36	28	19	24	18	16	19	293
	DN	0	1	4	4	7	2	7	6	7	11	49
	L	3	0	3	3	1	14	11	12	14	8	69
	R	2	2	2	7	14	15	8	14	13	12	89
3	UP	21	29	27	27	24	20	22	20	18	23	231
	DN	15	10	18	10	13	6	6	4	5	6	93
	L	9	3	2	7	4	12	10	14	13	10	84
	R	5	8	3	6	9	12	12	12	14	11	92
4	UP	36	44	26	24	23	22	23	22	19	17	256
	DN	1	0	5	3	7	6	4	4	5	5	40
	L	7	3	9	8	8	12	8	13	10	14	92
	R	6	3	10	15	12	10	15	11	16	14	112
5	UP	17	22	29	22	20	20	19	22	15	23	209
	DN	3	2	3	2	7	6	7	8	11	6	55
	L	18	17	10	13	9	13	12	10	13	14	129
	R	12	9	8	13	14	11	12	10	11	7	107

‡ The stimulus orientation indicated (UP/DN/L/R) is as seen in the mirror viewing aperture by the subject, and thus represents the precise orientation of the visual task posed.

Table 30A (II): The number and orientation‡ of individual stimulus presentations to each of five subjects over five runs comprising 100 stimuli per run.

SUBJECT NO.		STIMULUS NO. 0	8	1	9	4	5	2	3	6	7	: £%
1	UP	32	19	24	25	16	25	20	22	19	25	226
	DN	0	0	2	1	3	2	8	7	7	9	39
	L	15	20	15	20	17	12	13	9	15	9	146
	R	3	11	9	4	14	11	9	12	9	7	89
2	UP	41	45	43	41	20	15	16	21	18	21	281
	DN	5	3	3	1	4	9	7	8	6	11	57
	L	1	1	2	4	12	17	12	14	12	10	85
	R	3	1	2	4	14	9	15	7	14	8	77
3	UP	19	27	16	22	23	22	16	16	21	13	196
	DN	18	11	12	13	10	6	10	12	5	9	105
	L	10	8	8	13	12	11	16	12	18	18	126
	R	3	4	14	2	5	11	8	10	6	10	73
4	UP	29	39	33	26	34	23	27	14	19	14	258
	DN	1	1	3	0	3	4	11	9	9	9	50
	L	14	3	3	8	3	9	8	13	10	7	78
	R	6	7	11	16	10	14	4	14	12	20	114
5	UP	16	20	22	21	10	21	17	17	18	13	175
	DN	2	1	5	5	14	3	7	5	6	9	57
	L	24	19	9	3	9	15	10	16	13	20	138
	R	8	10	14	21	17	11	16	12	13	8	130

‡ The stimulus orientation indicated (UP/DN/L/R) is as seen in the mirror viewing aperture by the subject, and thus represents the precise orientation of the visual task posed.

Table 30B(I): Summary tables, one-way analysis of variance and Tukey's multiple comparison of means. Analysis undertaken on stimulus presentation data summed ($\mathcal{L}_o'$: Table 30A(I)) over the ten levels of stimulus angular subtense.

SOURCE	SUM SQUARES	df	MEAN SQUARE	F
Between - groups	94868.800	3	31622.933	43.954
Within - groups	11511.200	16	719.450	
TOTAL	106380.000	19		

F-ratio: result statistically significant, $p < 0.001$ (tabled value, 3/16 df : $F_{0.001} = 9.00$).

	$\overline{X}$ UP	$\overline{X}$ DN	$\overline{X}$ L	$\overline{X}$ R
$\overline{X}$ UP = 239.40	-	184.40 (62.25)**	136.00 (62.55)**	137.20 (62.25)**
$\overline{X}$ DN = 55.0	-	-	48.40 (48.58)NS	47.20 (48.58)NS
$\overline{X}$ L = 103.40	-	-	-	1.20 (48.58)NS
$\overline{X}$ R = 102.20	-	-	-	-

** $p < 0.01$ NS not statistically significant

CONSTANTS: $s = \sqrt{719.450/5} = 11.995$

$SR_{0.01} = 5.19$, $SR_{0.05} = 4.05$ (tabled values)

for V = 16 df and n = 4

Table 30B(II): Summary tables, one-way analysis of variance and Tukey's multiple comparison of means. Analysis undertaken on stimulus presentation data summed ($\mathcal{E}_o^9$: Table 30A(II)) over the ten levels of stimulus angular subtense.

SOURCE	SUM SQUARES	df	MEAN SQUARE	F
Between - groups	76895.600	3	25631.866	24.991
Within - groups	16410.400	16	1025.650	
TOTAL	93306.000	19		

F-ratio: result statistically significant, $p < 0.001$ (tabled value, 3/16 df : $F_{0.001} = 9.00$).

	$\overline{X}$ UP	$\overline{X}$ DN	$\overline{X}$ L	$\overline{X}$ R
$\overline{X}$ UP = 227.20	-	165.60 (74.33)**	112.60 (74.33)**	130.60 (74.33)**
$\overline{X}$ DN = 61.60	-	-	53.00 (58.00)NS	35.00 (58.00)NS
$\overline{X}$ L = 114.60	-	-	-	18.00 (58.00)NS
$\overline{X}$ R = 96.60	-	-	-	-

** $p < 0.01$ NS not statistically significant

CONSTANTS: $s = \sqrt{1025.650/5} = 14.332$

$SR_{0.01} = 5.19$, $SR_{0.05} = 4.05$ (tabled values)

for V = 16 df and n = 4

Table 30C(I): Summary table, two-way analysis of variance and Tukey's multiple comparison of means.
Analysis undertaken on individual stimulus presentation data (Table 30A(I)).

SOURCE OF VARIATION	SUM SQUARES	df	MEAN SQUARE	F+	(LEVEL)
BETWEEN - GROUPS	11330.800	39			
A STIMULUS ORIENTATION	9486.880	3	3162.293	145.761	(p ‹ 0.001)
B LEVEL OF STIMULUS ANGULAR SUBTENSE	0	9	0	0	(NS)
AB	1843.920	27	68.293	3.148	(p‹0.001)
WITHIN - GROUPS (ERROR)	3471.200	160	21.695		
TOTAL	14802.000	199			

+ F-ratios: Factor A and Interaction AB results statistically significant, p ‹ 0.001

(tabled values, 3/160 df : $F_{0.001} = 5.79$)
(27/160 df : $F_{0.001} = 2.26$)

continued/...

Table 30C(I): continued

	$\bar{X}$ UP	$\bar{X}$ DN	$\bar{X}$ L	$\bar{X}$ R
$\bar{X}$ UP = 23.94	-	18.44 (9.17)**	13.60 (9.17)**	13.72 (9.17)**
$\bar{X}$ DN = 5.50	-	-	4.84 (7.56)NS	4.72 (7.56)NS
$\bar{X}$ L = 10.34	-	-	-	0.12 (7.56)NS
$\bar{X}$ R = 10.22	-	-	-	-

** P < 0.01 NS not statistically significant

CONSTANTS : $s = \sqrt{21.695/5} = 2.083$

$SR_{0.01} = 4.40$, $SR_{0.05} = 3.63$ (tabled values)

for V = 160 df and n = 4

Table 30C(II): Summary tables, two-way analysis of variance and Tukey's multiple comparison of means.
Analysis undetaken on individual stimulus presentation data (Table 30A(II)).

SOURCE OF VARIATION	SUM SQUARES	df	MEAN SQUARE	F+	(LEVEL)
BETWEEN - GROUPS	9295.200	39			
A STIMULUS ORIENTATION	7679.000	3	2559.667	80.321	(p < 0.001)
B LEVEL OF STIMULUS ANGULAR SUBTENSE	0	9	0	0	(NS)
AB	1616.200	27	59.859	1.878	(p<0.01)
WITHIN - GROUPS (ERROR)	5098.800	160	31.868		
TOTAL	14394.000	199			

+ F-ratios: Factor A and Interaction AB results statistically significant, p < 0.001 and p<0.01 respectively

(tabled values, 3/160 df : $F_{0.001} = 5.79$)
(27/160 df : $F_{0.01} = 1.83$)

continued/...

Table 30D(I): Summary table, one-way analysis of variance. Analysis undertaken on individual stimulus presentation data under the break UP condition only (Table 30A(I)).

SOURCE OF VARIATION	SUM SQUARES	df	MEAN SQUARE	F†
BETWEEN - GROUPS	1110.020	9	123.336	2.874
WITHIN - GROUPS (ERROR)	1716.800	40	42.920	
TOTAL	2826.820	49		

† F-ratio: Result marginally statistically significant, $p < 0.025$
(tabled values, 9/40 df : $F_{0.025} = 2.45$)
($F_{0.01} = 2.89$)

Subsequent Tukey analysis revealed no significant comparisons of mean.

Table 30D(II): Summary table, one-way analysis of variance. Analysis undertaken on individual stimulus presentation data under the break UP condition only (Table 30A(II)).

SOURCE OF VARIATION	SUM SQUARES	df	MEAN SQUARE	F‡
BETWEEN - GROUPS	1014.080	9	112.676	1.970
WITHIN - GROUPS (ERROR)	2288.000	40	57.200	
TOTAL	3302.080	49		

‡ F-ratio: Result marginally statistically significant, $p < 0.1$
(tabled values, 9/40 df : $F_{0.1} = 1.79$)
($F_{0.05} = 2.12$)

Subsequent Tukey analysis revealed no significant comparisons of mean.

Table 31: The results of an investigation into the possible existence of a subjective guessing bias associated with the operation of the TV system (refer to Section 7.4Av, pages 192-196).

Subjective response data : N = 5 subjects.

Data Set (I) - Spectacle lens (monocular)

Data Set (II) - Soft contact lens (monocular)

On the basis of the two sets of subjective response data (Table 31 I,II), the utilisation of an analytical procedure after Prince and Fry (1958) reveals (Figure 19, page 195) no evidence of a subjective guessing bias associated with the operation of the TV system, despite the existence of a machine presentation bias (vide Table 30 : pages 302-311).

Table 31(I): Subjective response data (N = 5 subjects : Spectacle lens) - Refer to Figure 19A: Section 7.4Av.
For each orientation, $\overline{N}$ = No. calls; N_c = No. correct; $N_s = (4N_c - \overline{N})/3$ = No. actually seen.

Orientation +		STIMULUS NO. 0	8	1	9	4	5	2	3	6	7
UP	$\overline{N}$	107	72	105	93	87	100	100	100	88	104
	N_c	61	46	75	57	63	85	92	93	88	104
	N_s	45.67	37.33	65.00	45.00	55.00	80.00	89.33	90.67	88.00	104.00
DN	$\overline{N}$	35	61	38	37	52	26	36	28	29	36
	N_c	6	5	4	9	18	18	29	22	29	36
	N_s	-3.67	-13.67	-7.33	-0.33	6.67	15.33	26.67	20.00	29.00	36.00
L	$\overline{N}$	45	58	58	73	50	72	57	62	67	55
	N_c	7	7	14	16	9	54	50	60	67	55
	N_s	-5.67	-10.00	-0.67	-3.00	-4.67	48	47.67	59.33	67.00	55.00
R	$\overline{N}$	63	57	49	45	61	52	57	57	66	55
	N_c	8	6	6	12	34	46	49	57	66	55
	N_s	-10.33	-11.00	-8.33	1.00	25.00	44.00	46.33	57.00	66.00	55.00

+ Orientation of stimulus as seen in the mirror by the subject.

Table 31(II): Subjective response data (N = 5 subjects : Soft contact lens) - Refer to Figure 19B: Section 7.4Av. For each orientation, $\overline{N}$ = No. calls; N_c = No. correct; $N_s = (4N_c - \overline{N})/3$ = No. actually seen.

Orientation +		STIMULUS NO. 0	8	1	9	4	5	2	3	6	7
UP	$\overline{N}$	118	70	102	111	101	111	94	92	96	86
	N_c	73	43	60	65	63	96	90	89	96	86
	N_s	58.00	34.00	46.00	49.67	50.33	91.00	88.67	88.00	96.00	86.00
DN	$\overline{N}$	31	56	42	37	46	28	45	39	33	47
	N_c	5	8	9	3	15	20	42	39	33	47
	N_s	-3.67	-8.00	-2.00	-8.33	4.67	17.33	41.00	39.00	33.00	47.00
L	$\overline{N}$	55	67	52	54	46	58	60	63	68	64
	N_c	18	17	12	17	30	53	53	57	68	64
	N_s	5.67	0.33	-1.33	4.67	24.67	51.33	50.67	55.00	68.00	64.00
R	$\overline{N}$	44	56	55	49	54	53	48	56	51	53
	N_c	6	9	12	14	28	48	46	55	51	53
	N_s	-6.67	-6.67	-2.33	2.33	19.33	46.33	45.33	54.67	51.00	53.00

+ Orientation of stimulus as seen in the mirror by subject.

APPENDIX IV

STUDY NO. 4

Tabulations of the Experimental Data and Statistical Analyses

Table 32 : STUDY NO. 4 - Subjective TV scores, corrected for guessing (vide APPENDIX V: pages 426 - 430); mean result over three identical runs at selected control settings of the TV system.

(Checklist of TV system control settings: APPENDIX XIIID: page 504).

N = 50 eyes.

Table 32

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	1	0	0.22	4.22	9.11	10.00	1.56	8.22	10.00	10.00	1.56	0.89
		1	0.67	3.33	8.22	10.00	3.56	7.33	10.00	10.00	1.33	2.89
		2	0.89	0	7.33	10.00	4.22	6.89	10.00	10.00	2.67	2.89
		3	2.67	1.33	10.00	10.00	5.11	10.00	10.00	10.00	0	3.33
		4	1.33	2.89	10.00	10.00	5.11	10.00	10.00	10.00	1.11	2.44
		5	1.33	1.56	9.56	10.00	3.11	7.78	10.00	10.00	0.89	1.78
		6	2.67	1.11	9.56	10.00	6.44	9.11	10.00	10.00	0	1.33
2	1	0	1.11	1.78	9.11	10.00	2.89	6.89	10.00	10.00	0.22	0.89
		1	2.22	0.22	6.89	10.00	2.22	6.44	10.00	10.00	1.33	0.22
		2	1.78	1.33	8.67	9.11	0.67	4.67	10.00	10.00	0.22	2.44
		3	0.22	1.78	9.56	9.56	1.56	6.00	10.00	10.00	0.22	1.33
		4	0.22	1.78	8.22	9.56	2.00	6.00	10.00	10.00	0.22	1.11
		5	0	3.33	9.11	10.00	0	5.55	10.00	10.00	0.22	2.22
		6	0.22	1.11	9.11	10.00	5.11	9.11	10.00	10.00	1.11	1.56
3	2	0	0.89	0	8.67	9.11	1.11	4.67	10.00	10.00	1.78	2.00
		1	0.22	1.78	2.44	3.78	0.67	0.44	10.00	10.00	2.00	1.11
		2	1.56	0.44	4.22	4.22	1.11	2.44	10.00	10.00	1.56	1.78
		3	0.89	1.11	2.89	5.11	0.89	0.89	10.00	10.00	0.44	0
		4	0.22	1.78	6.89	8.22	0.89	2.89	10.00	10.00	0.22	2.22
		5	0.89	0.67	4.22	7.78	0.22	4.67	10.00	10.00	0.22	0.44
		6	0.89	2.89	7.78	9.11	3.78	4.22	10.00	10.00	0.89	1.33
4	2	0	1.33	0	2.44	5.55	1.33	4.00	10.00	10.00	0.44	1.33
		1	0.22	0.89	3.33	6.89	0.22	0.22	10.00	10.00	1.33	0.89
		2	0.89	2.00	5.11	9.56	2.00	4.22	10.00	10.00	1.11	1.33
		3	0	1.33	8.22	9.56	3.33	7.33	10.00	10.00	0.22	2.22
		4	1.78	0.44	8.67	10.00	3.78	3.78	10.00	10.00	1.33	1.33
		5	0.22	2.00	9.56	10.00	2.00	7.33	10.00	10.00	0.67	0.67
		6	0.89	1.78	8.22	10.00	3.78	6.89	10.00	10.00	0.22	2.22

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
5	3	0	0.22	0.22	2.89	6.00	0.89	1.11	10.00	10.00	0.44	0.89
		1	0.44	2.22	6.44	9.56	1.78	5.56	10.00	10.00	0.44	0.44
		2	0	0.89	6.44	8.67	0.22	2.67	10.00	10.00	1.78	0.89
		3	0.67	0.22	5.56	8.22	0.44	1.56	10.00	10.00	0.89	0.89
		4	0.22	0.44	9.56	10.00	0.89	4.67	10.00	10.00	0.89	1.11
		5	1.33	0	6.89	10.00	1.33	5.11	10.00	10.00	1.33	0.89
		6	0.89	0	6.89	10.00	0	2.89	10.00	10.00	0.44	1.78
6	3	0	0.67	0.67	2.00	3.78	0.44	0.89	10.00	10.00	0.44	0.22
		1	0.22	0.22	9.11	10.00	1.11	7.78	10.00	10.00	0.22	0.67
		2	1.11	0.67	9.56	10.00	2.89	6.89	10.00	10.00	0.67	0.67
		3	0.89	1.78	9.56	10.00	3.78	9.11	10.00	10.00	0	0.89
		4	0.22	0.22	10.00	10.00	4.22	9.56	10.00	10.00	0.89	0.22
		5	0.89	0.44	8.67	10.00	2.22	5.56	10.00	10.00	1.33	0.22
		6	1.56	0.67	6.89	9.56	0	5.11	10.00	10.00	2.44	1.56
7	4	0	2.22	0.89	7.78	10.00	1.11	6.00	10.00	10.00	0.89	0.22
		1	0	1.78	8.67	9.56	1.56	5.11	10.00	10.00	2.44	0.67
		2	0	0.22	6.89	10.00	2.22	4.67	10.00	10.00	0.22	0.67
		3	0	0.89	8.67	9.11	2.44	3.78	10.00	10.00	0.44	1.11
		4	1.56	0.67	6.89	9.56	6.00	5.11	10.00	10.00	1.11	1.56
		5	0.67	2.89	9.56	10.00	3.78	8.22	10.00	10.00	0.89	2.22
		6	-	-	-	-	-	-	-	-	-	-
8	4	0	1.11	1.11	9.56	9.56	5.56	8.67	10.00	10.00	1.56	2.00
		1	0.89	3.11	8.22	10.00	2.89	7.33	10.00	10.00	0.44	2.22
		2	1.33	0.44	10.00	10.00	2.44	6.44	10.00	10.00	0	2.22
		3	1.78	2.44	10.00	10.00	1.56	8.67	10.00	10.00	0.22	0.89
		4	0.67	2.00	9.56	10.00	4.67	4.22	10.00	10.00	0.67	2.00
		5	2.00	2.00	8.22	8.67	3.33	8.22	10.00	10.00	2.44	0.44
		6	1.56	1.78	9.56	10.00	5.11	5.11	10.00	10.00	0.22	1.33

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
9	5	0	0.44	2.00	7.33	9.56	1.33	2.00	10.00	10.00	0	0.67
		1	1.33	0.89	5.11	10.00	0	4.67	10.00	10.00	0.89	2.00
		2	2.00	2.00	4.67	9.11	1.78	0.44	10.00	10.00	1.33	1.33
		3	0.67	1.56	3.78	10.00	1.33	1.11	10.00	10.00	2.44	0.22
		4	3.78	1.33	5.56	9.11	0.44	5.56	10.00	10.00	1.33	0.89
		5	2.44	3.11	5.56	9.11	1.33	1.78	10.00	10.00	2.22	1.56
		6	3.78	6.00	6.00	8.67	2.22	2.67	10.00	10.00	0.89	4.22
10	5	0	0.89	1.56	3.78	8.22	1.78	2.22	10.00	10.00	0.67	0.89
		1	0.44	0.67	9.11	10.00	1.78	6.89	10.00	10.00	0.22	2.89
		2	0.89	1.11	7.78	9.11	0.44	2.44	10.00	10.00	0	1.11
		3	2.44	5.11	9.11	9.11	2.22	4.22	10.00	10.00	0.22	4.67
		4	2.44	2.67	10.00	10.00	6.00	7.78	10.00	10.00	0.22	2.22
		5	0.89	1.33	10.00	10.00	2.89	7.78	10.00	10.00	0	2.67
		6	5.11	3.33	9.11	10.00	5.56	9.56	10.00	10.00	1.33	3.33
11	6	0	0.44	1.56	10.00	10.00	2.89	9.56	10.00	10.00	0.44	1.11
		1	0.22	1.33	10.00	10.00	5.11	9.56	10.00	10.00	0.22	1.33
		2	0	2.00	9.56	10.00	5.56	9.11	10.00	10.00	0.89	0.44
		3	0.22	2.22	10.00	10.00	5.56	9.56	10.00	10.00	0.22	2.44
		4	0.89	2.44	10.00	10.00	6.89	9.56	10.00	10.00	0.89	4.22
		5	0	2.22	9.56	10.00	5.56	8.22	10.00	10.00	1.33	2.00
		6	0	1.78	9.56	10.00	3.33	8.67	10.00	10.00	0.22	0.22
12	6	0	0	1.11	8.67	9.56	3.78	6.89	10.00	10.00	0.67	0.22
		1	0.44	0.67	8.67	10.00	3.78	8.22	10.00	10.00	0.89	0.22
		2	0.22	0.44	9.11	9.56	1.33	6.44	10.00	10.00	0.89	1.56
		3	0.44	1.11	9.11	9.11	2.44	6.00	10.00	10.00	0.89	0.89
		4	0.89	1.33	9.56	10.00	2.00	9.11	10.00	10.00	0.67	1.11
		5	0.22	1.56	10.00	10.00	4.67	9.11	10.00	10.00	0.67	0.89
		6	0.89	1.78	10.00	10.00	2.89	6.89	10.00	10.00	2.22	1.33

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
13	7	0	1.56	0.44	9.56	10.00	2.44	8.67	10.00	10.00	0	4.00
		1	1.33	2.44	7.33	7.33	2.00	5.11	10.00	10.00	0.22	1.33
		2	2.89	2.67	10.00	9.56	4.67	9.56	10.00	10.00	0.67	2.89
		3	1.11	0.22	8.67	9.56	1.78	7.33	10.00	10.00	0.44	0.44
		4	2.89	2.44	9.56	10.00	5.56	9.11	10.00	10.00	0.44	2.44
		5	0.22	1.33	9.56	10.00	5.11	9.11	10.00	10.00	0.22	0.22
		6	1.33	3.33	10.00	10.00	7.33	9.56	10.00	10.00	1.33	4.67
14	7	0	1.11	2.67	9.11	10.00	2.44	8.22	10.00	10.00	1.33	0.89
		1	0	2.00	8.67	10.00	4.22	9.11	10.00	10.00	2.00	3.33
		2	1.78	3.78	10.00	10.00	5.56	8.67	10.00	10.00	1.78	3.78
		3	0.89	2.00	10.00	10.00	4.67	10.00	10.00	10.00	0.89	2.44
		4	2.00	3.33	10.00	9.56	3.33	9.11	10.00	10.00	1.33	3.78
		5	1.56	1.78	10.00	10.00	7.78	10.00	10.00	10.00	0.89	5.11
		6	1.56	4.22	10.00	10.00	4.67	8.67	10.00	10.00	0.67	1.33
15	8	0	0.22	1.33	7.33	10.00	5.56	7.78	10.00	10.00	0.44	1.78
		1	0.67	0.22	8.22	9.56	0.44	5.11	10.00	10.00	0	0.22
		2	1.33	0.22	6.89	10.00	0.44	4.22	10.00	10.00	0.89	2.89
		3	1.33	1.78	6.00	9.11	2.00	3.78	10.00	10.00	0.89	1.78
		4	1.56	2.67	9.11	10.00	0.89	9.56	10.00	10.00	1.33	2.44
		5	2.44	2.00	9.56	10.00	4.67	8.67	10.00	10.00	1.11	3.33
		6	1.33	2.22	9.11	10.00	1.33	6.44	10.00	10.00	0.67	0.89
16	9	0	0.22	0.44	2.00	7.33	0.67	2.44	10.00	10.00	0.22	0.22
		1	0	1.33	4.67	9.56	1.78	5.11	10.00	10.00	1.56	0.22
		2	0.89	1.11	9.56	9.56	6.00	9.11	10.00	10.00	0.67	0.44
		3	0.89	2.44	9.56	10.00	2.89	9.11	10.00	10.00	1.56	3.78
		4	1.11	1.78	10.00	10.00	2.67	7.33	10.00	10.00	0.44	2.44
		5	1.33	1.78	10.00	9.56	4.00	8.22	10.00	10.00	0	0.44
		6	1.78	0.89	8.22	10.00	3.33	8.22	10.00	10.00	1.56	1.33

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
17	9	0	0.67	2.44	9.56	9.56	1.33	5.11	10.00	10.00	1.78	2.00
		1	0.22	0.89	4.22	6.44	1.11	2.44	10.00	10.00	2.44	0.22
		2	0.44	0.44	5.56	8.67	1.56	2.67	10.00	10.00	0	2.22
		3	0.89	2.22	5.56	6.89	2.44	4.22	10.00	10.00	0.22	1.78
		4	0.67	0.89	2.22	9.11	0.89	2.89	10.00	10.00	1.11	0.89
		5	0.22	0.22	4.67	8.22	1.33	3.78	10.00	10.00	0.22	0.67
		6	1.78	0.67	3.78	7.33	1.33	2.22	10.00	10.00	0	0.67
18	10	0	2.22	0.67	4.67	10.00	0.44	4.67	10.00	10.00	0	0.89
		1	1.33	2.00	7.78	9.11	0.67	6.89	10.00	10.00	0.67	1.33
		2	0.22	2.22	6.00	7.78	1.78	4.22	10.00	10.00	0.67	0.22
		3	0.89	1.56	5.11	8.67	0.22	2.22	10.00	10.00	0.89	3.11
		4	4.11	0.22	5.11	7.78	0.89	2.44	10.00	10.00	0.67	1.11
		5	0.89	1.56	7.33	8.67	1.11	3.33	10.00	10.00	0.22	1.56
		6	2.22	1.56	6.44	8.22	0.67	4.67	10.00	10.00	0.22	0.89
19	10	0	1.78	1.56	6.44	10.00	1.56	3.78	10.00	10.00	1.11	0.22
		1	2.89	0.22	7.33	10.00	2.67	6.44	10.00	10.00	1.56	2.44
		2	4.67	0.67	4.22	9.11	1.33	4.67	10.00	10.00	0.22	2.44
		3	2.22	0.22	6.00	8.22	2.00	2.44	10.00	10.00	2.44	1.11
		4	0	1.33	3.78	8.67	0.67	3.33	10.00	10.00	0.67	1.33
		5	1.56	1.11	6.44	9.56	2.89	4.67	10.00	10.00	1.33	1.78
		6	1.78	0	9.11	9.56	2.89	3.78	10.00	10.00	1.11	2.44
20	11	0	0.89	1.11	9.56	10.00	4.67	8.22	10.00	10.00	0	1.78
		1	0.22	5.56	10.00	10.00	3.78	7.78	10.00	10.00	0.67	1.56
		2	0.22	1.78	10.00	10.00	3.78	9.11	10.00	10.00	0.44	0.22
		3	0	1.11	10.00	10.00	3.78	8.67	10.00	10.00	0	2.44
		4	0.44	2.00	7.33	9.56	2.00	4.67	10.00	10.00	0.89	1.33
		5	0.44	0.89	8.67	10.00	0.22	4.22	10.00	10.00	1.78	0.22
		6	0.44	2.67	9.56	10.00	3.33	6.89	10.00	10.00	0.67	2.67

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
21	11	0	0.22	2.89	10.00	10.00	3.56	9.56	10.00	10.00	2.22	1.11
		1	2.22	1.78	8.67	9.11	1.78	6.44	10.00	10.00	2.00	0.89
		2	0.89	1.56	4.22	8.22	1.56	2.89	10.00	10.00	0.67	0.44
		3	1.11	0.89	8.22	9.11	1.56	5.11	10.00	10.00	0.22	2.22
		4	1.33	0.22	6.00	4.67	2.00	2.22	10.00	10.00	1.11	0.44
		5	2.44	0.89	7.78	9.56	0.67	4.67	10.00	10.00	0.22	0.67
		6	1.11	1.78	8.22	9.56	3.33	7.33	10.00	10.00	1.11	1.33
22	12	0	0.22	2.00	5.56	8.67	2.45	6.45	10.00	10.00	0.67	1.56
		1	0	1.78	3.33	6.89	0.44	2.44	10.00	10.00	1.33	0.89
		2	1.11	1.78	5.56	5.56	3.11	3.33	10.00	10.00	1.33	1.56
		3	1.56	2.89	8.67	10.00	5.11	8.67	10.00	10.00	0.22	1.78
		4	2.00	1.56	9.56	10.00	2.89	7.33	10.00	10.00	0.89	2.22
		5	1.56	2.89	8.67	9.56	3.33	7.78	10.00	10.00	0.44	2.44
		6	-	-	-	-	-	-	-	-	-	-
23	13	0	0.89	1.33	10.00	10.00	5.56	7.78	10.00	10.00	0.89	1.56
		1	2.44	2.44	8.67	9.56	3.78	9.11	10.00	10.00	1.78	0.89
		2	0.89	1.33	9.11	10.00	6.00	8.67	10.00	10.00	1.78	2.22
		3	1.33	2.89	10.00	10.00	3.56	6.89	10.00	10.00	0.22	2.22
		4	0.67	3.33	10.00	10.00	3.33	9.56	10.00	10.00	0.89	1.78
		5	2.22	1.78	9.56	10.00	4.22	9.11	10.00	10.00	1.11	3.33
		6	2.44	2.44	10.00	10.00	4.22	8.67	10.00	10.00	2.00	0.67
24	13	0	0.44	2.00	9.11	10.00	4.67	9.11	10.00	10.00	1.78	0.67
		1	1.33	0	8.67	10.00	6.00	9.11	10.00	10.00	1.56	3.56
		2	3.11	2.00	9.56	10.00	5.11	8.67	10.00	10.00	0.67	2.89
		3	1.56	2.89	10.00	10.00	6.00	10.00	10.00	10.00	0.67	2.00
		4	2.00	0.22	10.00	10.00	4.22	9.56	10.00	10.00	0.89	1.56
		5	1.78	0.67	8.22	9.56	1.11	6.44	10.00	10.00	0	2.00
		6	2.44	3.33	10.00	10.00	6.44	9.11	10.00	10.00	0	2.00

Table 32: continued

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
25	14	0	0.89	0	9.11	10.00	4.67	8.22	10.00	10.00	0.22	0.22
		1	0.22	1.56	7.78	10.00	2.89	6.89	10.00	10.00	0.22	1.11
		2	0	1.78	9.56	9.11	5.11	9.56	10.00	10.00	0.22	1.56
		3	0.22	1.56	10.00	9.56	3.33	7.33	10.00	10.00	0.44	1.11
		4	0.67	2.22	9.56	10.00	4.22	9.56	10.00	10.00	0	2.00
		5	0.67	2.22	9.56	10.00	6.00	9.56	10.00	10.00	0.44	3.11
		6	0.67	0.44	9.11	10.00	1.33	7.78	10.00	10.00	0.22	0.44
26	14	0	0	0	7.33	10.00	0.22	7.78	10.00	10.00	0.67	1.11
		1	1.56	0.67	6.89	9.56	3.33	7.33	10.00	10.00	0.22	0
		2	0.67	0	8.22	10.00	2.44	5.56	10.00	10.00	0.22	0.67
		3	0.67	2.89	8.67	10.00	0.89	6.00	10.00	10.00	1.11	0.44
		4	0.67	2.67	9.11	10.00	2.67	7.78	10.00	10.00	0.44	1.33
		5	0	0.89	10.00	10.00	2.22	7.33	10.00	10.00	0.22	1.11
		6	2.22	1.33	9.56	10.00	2.44	7.33	10.00	10.00	0.67	0.89
27	15	0	0.22	0.44	9.56	9.56	1.33	8.22	10.00	10.00	0.22	0.89
		1	1.11	2.00	9.11	10.00	5.56	7.78	10.00	10.00	0.22	0.89
		2	0.44	0.89	10.00	10.00	4.22	8.67	10.00	10.00	0	1.56
		3	0.89	3.33	10.00	10.00	6.89	10.00	10.00	10.00	1.33	4.22
		4	0	0.89	9.56	10.00	6.89	9.11	10.00	10.00	0.67	1.56
		5	0.89	2.44	9.56	10.00	3.78	7.33	10.00	10.00	0.67	0.89
		6	0.67	2.22	10.00	10.00	3.78	8.67	10.00	10.00	0.89	1.11
28	15	0	0.89	1.56	6.00	9.11	2.00	5.56	10.00	10.00	0	0.44
		1	1.78	0.89	9.11	10.00	4.67	9.11	10.00	10.00	0.67	1.56
		2	1.11	0.44	10.00	9.56	2.89	7.78	10.00	10.00	0.22	2.67
		3	0.22	1.33	9.11	10.00	3.33	10.00	10.00	10.00	0.89	1.11
		4	0.44	1.78	10.00	10.00	2.89	8.67	10.00	10.00	0.89	2.67
		5	0.22	0.89	8.67	10.00	3.33	6.44	10.00	10.00	0.67	0.67
		6	0.67	2.89	9.11	10.00	4.67	4.67	10.00	10.00	1.78	0.44

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
29	16	0	1.78	1.78	6.00	8.67	0.22	2.00	10.00	10.00	0.67	0
		1	0.22	0	9.11	9.11	0.89	6.00	10.00	10.00	1.33	2.89
		2	1.11	0.89	8.67	10.00	3.11	6.44	10.00	10.00	0.89	0.44
		3	0	0.22	9.56	10.00	2.89	9.11	10.00	10.00	1.11	0.22
		4	1.78	0.67	9.56	10.00	2.89	8.22	10.00	10.00	1.33	0.44
		5	0.22	2.22	10.00	9.56	1.78	9.56	10.00	10.00	0.44	1.78
		6	0.44	2.00	9.11	10.00	1.33	6.44	10.00	10.00	0.44	1.11
30	16	0	1.33	0.67	9.11	10.00	4.22	7.78	10.00	10.00	1.33	0.67
		1	1.11	0.44	10.00	10.00	2.89	8.22	10.00	10.00	1.78	0.22
		2	1.78	2.22	8.22	10.00	1.33	9.11	10.00	10.00	1.11	2.00
		3	2.00	2.44	8.67	10.00	3.33	7.78	10.00	10.00	0.67	1.78
		4	1.33	1.33	8.22	10.00	5.11	6.00	10.00	10.00	0.89	2.67
		5	-	-	-	-	-	-	-	-	-	-
		6	0.22	2.22	10.00	9.56	2.44	6.89	10.00	10.00	0.44	0.89
31	17	0	1.33	1.78	9.56	10.00	3.33	9.11	10.00	10.00	0.44	0
		1	0	1.33	9.56	10.00	1.33	7.33	10.00	10.00	0.67	0.89
		2	0.44	1.11	10.00	10.00	5.11	10.00	10.00	10.00	0.22	0
		3	0.22	0.89	10.00	10.00	7.78	10.00	10.00	10.00	0.67	0.89
		4	2.44	1.78	10.00	10.00	6.44	10.00	10.00	10.00	1.56	0.89
		5	1.33	0.67	10.00	10.00	4.67	9.56	10.00	10.00	0.22	1.11
		6	0.44	1.33	9.56	10.00	5.11	9.56	10.00	10.00	1.33	1.33
32	17	0	0	1.33	9.11	10.00	3.33	8.22	10.00	10.00	0.22	0
		1	0	2.44	10.00	10.00	5.11	8.67	10.00	10.00	0	2.44
		2	0.67	0.67	10.00	10.00	4.67	8.67	10.00	10.00	1.78	0
		3	0.22	3.78	8.67	10.00	4.67	9.56	10.00	10.00	0.22	0.44
		4	1.33	0.44	9.56	10.00	3.33	9.56	10.00	10.00	0.67	1.33
		5	0	1.11	10.00	10.00	3.78	10.00	10.00	10.00	0.22	1.78
		6	0	0.22	10.00	10.00	3.78	7.33	10.00	10.00	0.67	0.67

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
33	18	0	0.44	0.67	6.00	9.11	0	2.22	10.00	10.00	0	0.67
		1	2.00	1.11	10.00	10.00	4.67	10.00	10.00	10.00	0.22	1.33
		2	2.44	2.00	10.00	10.00	7.33	10.00	10.00	10.00	0.22	1.56
		3	1.78	3.33	10.00	10.00	6.44	9.56	10.00	10.00	1.33	3.78
		4	0.67	1.56	10.00	9.56	2.89	8.22	10.00	10.00	0.67	2.22
		5	0.67	1.78	8.67	9.11	2.89	7.33	10.00	10.00	0	1.56
		6	0.67	3.33	8.22	9.56	3.33	8.22	10.00	10.00	2.00	0.22
34	18	0	1.78	1.33	6.44	9.56	0.44	7.33	10.00	10.00	1.33	0.89
		1	2.22	1.11	9.56	10.00	5.11	8.22	10.00	10.00	2.00	0.67
		2	0.89	2.89	9.56	10.00	4.11	5.11	10.00	10.00	1.11	3.56
		3	2.89	1.56	5.56	9.56	1.56	3.33	10.00	10.00	1.11	0.44
		4	0.67	1.78	9.11	9.56	2.22	5.11	10.00	10.00	2.00	2.44
		5	0	0.67	8.67	9.11	2.44	7.33	10.00	10.00	1.11	1.56
		6	3.78	2.44	10.00	10.00	3.78	7.78	10.00	10.00	0.22	2.22
35	19	0	0.44	1.33	9.56	9.56	4.22	7.78	10.00	10.00	0	2.22
		1	1.56	2.44	8.22	8.67	6.89	9.11	10.00	10.00	0.67	2.89
		2	0.44	2.89	10.00	10.00	6.44	9.11	10.00	10.00	0.44	2.00
		3	1.11	2.89	9.56	10.00	6.00	8.22	10.00	10.00	0.67	0.22
		4	0.67	1.11	9.56	9.56	1.11	7.78	10.00	10.00	0	0.67
		5	0.44	1.56	6.00	10.00	2.44	4.67	10.00	10.00	1.33	1.33
		6	0.22	1.33	7.33	8.67	1.11	3.78	10.00	10.00	0.44	0.22
36	19	0	0.89	2.22	8.67	10.00	0.22	4.67	10.00	10.00	2.00	1.78
		1	0.67	2.44	9.56	10.00	6.00	10.00	10.00	10.00	0	1.33
		2	0	4.22	9.56	10.00	5.11	7.78	10.00	10.00	1.11	2.00
		3	1.11	0.67	10.00	9.56	2.89	9.56	10.00	10.00	0.22	0.44
		4	1.33	3.33	9.56	10.00	3.33	8.67	10.00	10.00	0	1.78
		5	1.11	1.11	8.22	9.56	4.67	10.00	10.00	10.00	0.22	2.89
		6	0	2.00	10.00	10.00	2.22	7.33	10.00	10.00	1.11	0.89

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
37	20	0	0.67	0.22	9.56	10.00	2.44	7.33	10.00	10.00	0.44	1.33
		1	0.22	1.56	6.45	10.00	1.56	7.33	10.00	10.00	0.67	0.44
		2	1.33	1.78	8.67	9.56	4.67	6.44	10.00	10.00	0.44	0.44
		3	0.89	0.44	9.11	10.00	2.00	7.33	10.00	10.00	0.22	0.89
		4	1.78	2.22	9.56	10.00	3.78	8.67	10.00	10.00	0.89	0.67
		5	2.67	0.89	10.00	10.00	4.22	7.78	10.00	10.00	0.44	0.67
		6	0.22	0.67	10.00	10.00	2.89	9.11	10.00	10.00	0	0.67
38	20	0	0.22	1.11	8.67	10.00	0.89	8.67	10.00	10.00	1.78	0.22
		1	1.78	0	9.56	10.00	3.33	7.78	10.00	10.00	0.89	2.44
		2	0.22	2.00	10.00	10.00	5.56	9.56	10.00	10.00	0.67	0.44
		3	1.56	1.78	9.56	9.56	1.56	9.56	10.00	10.00	0.67	0.67
		4	1.33	1.33	10.00	10.00	2.44	8.67	10.00	10.00	2.89	1.33
		5	1.56	3.33	10.00	10.00	6.44	8.67	10.00	10.00	1.33	3.78
		6	0	1.56	10.00	10.00	7.56	10.00	10.00	10.00	0.44	1.33
39	21	0	0.67	2.00	7.78	10.00	1.56	6.89	10.00	10.00	0	3.78
		1	0	0.44	9.11	10.00	3.33	8.22	10.00	10.00	1.33	1.78
		2	1.78	3.56	10.00	10.00	6.00	7.33	10.00	10.00	0.22	2.67
		3	0.67	0	9.11	10.00	2.44	8.67	10.00	10.00	1.33	1.33
		4	2.22	0.44	9.56	10.00	2.89	6.00	10.00	10.00	0	0.89
		5	1.33	0.44	9.11	10.00	2.44	9.56	10.00	10.00	0.22	2.67
		6	0.67	1.11	10.00	10.00	5.11	8.22	10.00	10.00	0.44	2.00
40	21	0	1.33	1.78	9.56	10.00	6.45	9.11	10.00	10.00	0.22	0.22
		1	0.89	2.44	9.56	10.00	7.33	9.56	10.00	10.00	0.89	4.67
		2	0.22	2.89	9.56	10.00	3.33	8.67	10.00	10.00	0.89	2.89
		3	2.89	0.67	10.00	10.00	4.22	8.67	10.00	10.00	0.67	2.67
		4	0	0.89	8.67	10.00	5.56	7.78	10.00	10.00	1.33	3.33
		5	2.00	1.11	10.00	10.00	6.00	9.11	10.00	10.00	0.44	3.11
		6	0.67	2.89	10.00	10.00	8.22	10.00	10.00	10.00	1.56	1.56

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
41	22	0	0.44	1.78	8.67	10.00	2.44	6.44	10.00	10.00	0	2.44
		1	0.22	0.67	9.11	9.56	3.33	7.78	10.00	10.00	0.22	1.78
		2	0.22	1.56	9.56	10.00	3.78	8.22	10.00	10.00	0.44	0.89
		3	0.22	0.67	8.22	9.56	4.22	8.67	10.00	10.00	2.44	1.33
		4	0.44	0	9.56	9.56	4.22	8.22	10.00	10.00	1.33	0.89
		5	0	0.22	4.67	8.67	1.11	3.33	10.00	10.00	1.78	0.89
		6	0.22	0.89	6.00	8.67	1.56	4.67	10.00	10.00	0.67	1.78
42	23	0	1.11	2.22	10.00	10.00	2.22	9.56	10.00	10.00	1.56	1.56
		1	0.44	3.33	9.56	10.00	5.11	9.11	10.00	10.00	1.11	0.89
		2	6.44	5.11	10.00	10.00	6.89	7.78	10.00	10.00	0.22	4.22
		3	2.00	0.22	10.00	10.00	6.44	9.11	10.00	10.00	2.22	4.67
		4	1.78	0.44	8.67	10.00	1.56	7.78	10.00	10.00	0.67	1.78
		5	2.67	3.33	10.00	10.00	4.67	6.44	10.00	10.00	0.22	0.44
		6	0.67	3.33	10.00	10.00	6.44	9.56	10.00	10.00	0.89	2.89
43	23	0	4.22	0.89	6.89	10.00	0.22	3.78	10.00	10.00	0.67	2.44
		1	0.67	0.89	7.78	10.00	4.22	9.11	10.00	10.00	0.89	1.33
		2	3.78	3.56	8.22	8.67	3.78	5.11	10.00	10.00	1.33	3.11
		3	1.78	2.22	9.56	9.56	3.33	8.67	10.00	10.00	1.11	1.33
		4	1.56	2.89	9.56	10.00	2.44	9.56	10.00	10.00	1.56	2.22
		5	0.89	2.89	9.56	9.56	4.22	9.56	10.00	10.00	0.89	3.78
		6	3.33	1.78	10.00	10.00	4.67	9.56	10.00	10.00	0.22	1.78
44	24	0	0.22	2.44	2.22	10.00	2.44	6.44	10.00	10.00	2.22	1.78
		1	0	4.22	9.11	10.00	3.78	10.00	10.00	10.00	0.44	1.56
		2	1.33	3.33	9.56	10.00	4.67	8.67	10.00	10.00	1.78	2.89
		3	0.44	2.67	9.56	10.00	3.33	7.33	10.00	10.00	0.44	2.22
		4	1.33	1.33	9.56	10.00	4.22	4.67	10.00	10.00	1.33	0.89
		5	0.89	2.22	8.67	10.00	4.22	8.22	10.00	10.00	0.67	2.22
		6	0.89	1.56	10.00	10.00	3.78	9.56	10.00	10.00	0.22	0

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
45	25	0	0.44	0	9.11	10.00	2.67	8.22	10.00	10.00	0	0.22
		1	1.33	1.33	9.11	10.00	5.11	10.00	10.00	10.00	1.11	0.89
		2	1.33	0.44	10.00	10.00	5.56	8.22	10.00	10.00	2.89	2.44
		3	1.78	3.78	10.00	9.56	6.44	10.00	10.00	10.00	0.67	2.44
		4	0.67	3.33	10.00	10.00	6.89	8.22	10.00	10.00	0.67	3.78
		5	1.78	1.56	10.00	10.00	7.33	8.22	10.00	10.00	0	2.00
		6	0.89	3.78	9.56	10.00	7.33	9.56	10.00	10.00	0.67	1.33
46	25	0	1.33	1.78	9.56	10.00	4.22	9.56	10.00	10.00	1.33	1.33
		1	0.89	0	10.00	10.00	5.11	8.67	10.00	10.00	0	1.11
		2	0.44	2.44	10.00	10.00	5.56	9.56	10.00	10.00	0.22	4.00
		3	1.78	1.56	9.56	9.11	2.89	8.67	10.00	10.00	0.67	2.22
		4	2.89	1.78	9.56	10.00	5.11	9.56	10.00	10.00	1.33	1.33
		5	2.44	0.89	9.56	9.56	4.00	6.89	10.00	10.00	1.33	1.33
		6	0.22	0.89	9.56	10.00	2.00	7.78	10.00	10.00	0.22	0.67
47	26	0	0.22	0.89	6.45	9.11	1.56	5.11	10.00	10.00	0.22	0
		1	1.78	0.44	9.11	10.00	3.78	8.67	10.00	10.00	2.00	0.22
		2	0.22	2.89	9.56	10.00	8.22	9.11	10.00	10.00	0.44	3.11
		3	1.11	2.00	9.56	9.11	6.89	9.56	10.00	10.00	0	3.11
		4	0.89	1.33	8.22	9.56	2.89	7.78	10.00	10.00	2.00	0.67
		5	0.89	1.11	7.33	9.56	0.89	3.78	10.00	10.00	0	1.78
		6	0	0.67	9.56	10.00	3.78	9.11	10.00	10.00	0.44	1.78
48	26	0	0	0	6.00	9.56	3.33	4.22	10.00	10.00	0	0.67
		1	0.89	2.67	10.00	10.00	7.33	8.67	10.00	10.00	1.33	1.56
		2	1.11	2.00	10.00	9.56	7.78	9.56	10.00	10.00	0.67	2.22
		3	0.22	1.33	10.00	10.00	6.44	9.11	10.00	10.00	2.67	1.33
		4	0.89	0.22	9.56	10.00	3.78	8.22	10.00	10.00	1.33	1.33
		5	0	1.11	9.56	9.56	3.78	9.56	10.00	10.00	0.44	0.89
		6	0.44	2.67	10.00	10.00	3.33	10.00	10.00	10.00	0.67	1.33

Table 32 (continued)

Eye No.	Subject No.	Visit No.	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
49	27	0	0.22	1.11	4.22	3.78	0.67	1.11	10.00	10.00	1.11	0.22
		1	0.22	0.67	5.56	10.00	3.11	5.56	10.00	10.00	0.89	1.11
		2	1.78	0.44	6.44	10.00	2.67	5.11	10.00	10.00	0.22	2.22
		3	1.78	2.67	8.67	10.00	1.11	4.67	10.00	10.00	1.33	1.33
		4	0.22	1.11	6.89	9.56	1.33	3.78	10.00	10.00	0.22	0.44
		5	0.22	3.11	7.78	10.00	5.11	4.67	10.00	10.00	1.11	1.78
		6	-	-	-	-	-	-	-	-	-	-
50	27	0	1.33	0.67	8.67	9.11	0.44	4.67	10.00	10.00	1.33	1.11
		1	0.67	0.67	9.56	10.00	4.00	8.22	10.00	10.00	0.22	1.11
		2	0.89	2.00	9.56	10.00	6.00	8.22	10.00	10.00	0.22	1.11
		3	1.11	4.22	9.56	10.00	3.56	7.78	10.00	10.00	0.44	4.67
		4	0.89	1.33	8.22	9.11	2.44	3.78	10.00	10.00	0	0.22
		5	0	1.33	6.89	9.56	3.33	6.89	10.00	10.00	1.56	2.44
		6	-	-	-	-	-	-	-	-	-	-

Table 33 : STUDY NO. 4 - Subjective latency of response data (unit of measurement : s); mean result, as per the validated 20% data sampling procedure (TABLE 38C: pages 417 - 425), over three identical runs at selected control settings of the TV system.

(Checklist of TV system control settings: APPENDIX XIIID: page 504).

N = 50 eyes.

Table 33:

Subject Eye	No.	Visit	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	1	0	1.07	0.93	0.85	0.80	1.07	0.85	0.67	0.68	0.90	1.00
		1	0.93	1.13	0.88	0.67	0.95	1.00	0.68	0.60	0.97	1.12
		2	1.05	0.88	0.73	0.60	0.88	0.77	0.62	0.58	0.85	0.92
		3	0.98	1.10	0.82	0.73	0.98	0.87	0.73	0.65	1.07	1.05
		4	1.03	1.05	0.87	0.77	1.13	0.98	0.67	0.65	1.02	1.03
		5	0.95	1.03	0.88	0.82	1.08	0.98	0.73	0.72	0.95	0.98
		6	1.30	1.53	0.88	0.77	1.35	0.90	0.77	0.73	1.40	1.32
2	1	0	1.03	1.00	0.95	0.77	1.03	0.92	0.72	0.65	1.20	1.03
		1	0.88	1.08	0.97	0.95	0.92	1.08	0.83	0.67	0.98	0.85
		2	0.65	0.73	0.85	0.82	0.73	0.83	0.62	0.55	0.65	0.75
		3	0.88	0.87	0.87	0.78	1.02	0.92	0.67	0.63	0.78	0.90
		4	0.90	1.05	0.88	0.80	1.15	1.20	0.82	0.73	0.95	0.95
		5	0.88	1.02	1.05	0.82	1.02	1.15	0.77	0.63	0.87	1.02
		6	1.12	1.53	1.12	0.83	1.17	1.05	0.78	0.72	1.33	1.47
3	2	0	1.57	1.42	1.30	1.02	1.52	1.37	1.00	0.92	1.35	1.45
		1	1.17	0.87	1.07	0.97	0.92	1.05	0.92	0.88	0.95	1.20
		2	1.00	1.33	1.28	1.23	1.30	1.08	1.00	0.83	1.13	1.12
		3	1.02	1.18	1.17	1.48	1.08	1.27	1.00	1.00	0.85	1.13
		4	1.32	1.23	1.62	1.27	1.38	1.30	0.97	0.92	1.45	1.50
		5	1.62	1.57	1.73	1.80	1.55	1.47	1.17	0.98	1.68	1.47
		6	1.55	1.60	1.62	0.98	1.55	1.43	0.97	0.88	1.60	1.78
4	2	0	1.58	1.57	1.82	1.43	1.32	1.28	1.07	0.83	1.72	1.47
		1	1.22	1.07	1.15	1.12	1.13	1.17	1.03	0.85	1.12	1.17
		2	1.03	1.08	1.25	1.08	1.07	0.98	0.92	0.80	1.18	1.05
		3	1.30	1.28	1.25	1.17	1.25	1.30	0.98	0.83	1.32	1.33
		4	1.52	1.43	1.23	0.97	1.15	1.38	0.82	0.83	1.58	1.62
		5	1.77	1.60	0.95	0.98	1.32	1.18	1.00	0.73	1.60	1.67
		6	1.58	1.68	1.17	1.08	1.35	1.33	1.02	0.80	1.75	1.80
5	3	0	1.08	1.32	1.58	1.32	1.27	1.18	1.17	1.08	1.12	1.07
		1	1.27	1.28	1.57	1.53	1.38	1.28	1.08	1.08	1.10	0.97
		2	1.32	1.03	1.62	1.40	1.35	1.33	1.05	0.87	1.07	0.87
		3	0.88	1.32	1.62	1.27	0.95	1.40	0.85	0.77	1.07	0.80
		4	1.38	1.42	1.60	0.82	1.17	1.22	0.70	0.75	1.12	1.28
		5	1.10	1.23	1.23	0.88	1.08	1.13	0.78	0.82	0.95	1.23
		6	1.37	1.35	1.57	1.05	1.22	1.25	0.93	0.80	1.10	1.12
6	3	0	0.98	1.18	1.52	1.27	1.03	1.42	0.98	1.00	1.03	1.08
		1	1.38	1.67	1.60	1.08	1.33	1.13	0.87	0.72	1.18	1.25
		2	0.95	1.32	1.27	0.82	1.07	1.23	0.77	0.75	1.08	1.02
		3	1.23	1.28	0.80	0.68	1.18	0.93	0.58	0.73	0.97	1.27
		4	1.47	1.32	0.87	0.68	0.95	1.00	0.68	0.72	1.10	1.20
		5	1.05	1.12	1.30	0.85	1.00	0.93	0.72	0.80	1.13	1.00
		6	1.12	0.90	1.43	0.90	1.37	1.40	0.85	0.67	1.08	0.93

Table 33: Continued

Subject Eye	No.	Visit	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
7	4	0	2.42	2.32	2.23	1.58	2.05	1.77	1.08	1.00	2.37	1.97
		1	2.17	2.15	1.47	0.97	2.03	1.88	0.93	0.85	2.17	1.65
		2	2.18	2.32	1.88	1.25	2.10	1.95	0.85	0.78	2.03	2.22
		3	1.88	2.10	1.95	1.25	2.15	1.95	0.98	0.92	2.03	2.00
		4	2.38	2.18	2.23	1.18	2.18	2.23	1.03	0.82	2.28	2.28
		5	2.08	2.52	1.60	1.13	2.33	2.10	0.97	0.82	1.92	2.42
		6	-	-	-	-	-	-	-	-	-	-
8	4	0	1.80	2.12	1.27	1.08	1.57	1.80	0.87	0.88	1.88	2.02
		1	1.87	2.07	1.47	1.10	1.73	1.72	0.75	0.73	1.75	1.78
		2	2.18	1.85	1.68	0.88	1.60	1.82	0.87	0.83	1.82	2.00
		3	2.10	2.00	1.42	0.95	2.15	1.42	0.87	0.70	0.98	1.97
		4	1.85	2.23	1.67	1.02	1.95	2.10	0.97	0.88	1.72	2.13
		5	2.23	2.27	1.67	1.22	2.07	1.98	0.95	0.77	2.12	2.32
		6	2.25	2.25	2.20	1.12	2.12	2.42	1.05	0.90	1.93	2.10
9	5	0	0.98	1.00	0.90	0.90	1.05	1.00	0.75	0.70	1.23	1.05
		1	0.82	0.90	1.32	0.70	1.03	0.87	0.60	0.58	0.95	1.03
		2	0.57	0.85	1.13	0.78	0.92	0.97	0.57	0.53	0.77	0.73
		3	0.60	0.73	0.85	0.72	0.75	0.73	0.62	0.60	0.82	0.70
		4	0.62	0.77	1.00	0.73	0.77	0.95	0.75	0.65	0.67	0.80
		5	0.87	0.80	1.10	0.78	0.78	1.05	0.65	0.62	0.62	0.80
		6	0.57	0.72	1.07	0.75	0.76	0.87	0.63	0.57	0.78	0.63
10	5	0	0.70	0.88	0.98	0.95	0.77	0.93	0.82	0.67	1.00	0.75
		1	0.55	0.88	0.70	0.65	0.92	0.80	0.55	0.52	0.80	0.90
		2	0.57	0.62	0.83	0.62	0.77	0.83	0.58	0.53	0.68	0.73
		3	0.67	0.55	0.78	0.68	0.62	0.88	0.55	0.58	0.72	0.57
		4	0.62	0.78	0.75	0.57	0.88	0.83	0.53	0.53	0.78	0.78
		5	0.65	0.88	0.67	0.57	0.88	0.97	0.53	0.58	0.58	0.92
		6	0.62	0.77	0.72	0.68	0.90	0.85	0.63	0.60	0.58	0.68
11	6	0	1.00	0.95	0.97	0.77	1.13	1.02	0.75	0.77	1.08	1.07
		1	0.97	0.97	0.77	0.72	0.90	0.87	0.77	0.58	0.98	1.13
		2	0.85	1.08	0.92	0.83	1.10	0.87	0.67	0.63	1.07	0.95
		3	0.92	0.83	0.67	0.78	0.88	0.75	0.65	0.53	0.75	0.98
		4	1.00	0.87	0.65	0.63	0.90	0.80	0.63	0.58	0.77	1.08
		5	0.75	0.80	1.08	0.78	1.03	1.00	0.70	0.70	0.65	0.80
		6	0.73	0.88	0.95	0.72	1.03	0.98	0.68	0.72	0.72	0.78
12	6	0	0.95	0.88	1.13	0.95	0.97	0.97	0.82	0.88	1.08	0.97
		1	0.95	0.92	0.97	0.95	1.08	0.87	0.85	0.75	1.03	1.02
		2	0.77	1.13	0.88	0.75	1.20	1.12	0.83	0.75	0.93	0.97
		3	0.83	0.77	0.78	0.85	0.78	0.82	0.68	0.63	0.68	0.80
		4	0.72	0.80	0.85	0.70	0.98	0.92	0.70	0.65	0.60	0.75
		5	0.82	0.82	0.88	0.67	0.90	0.90	0.82	0.58	0.70	0.72
		6	0.83	0.72	0.70	0.75	1.02	0.72	0.63	0.65	0.72	0.92

Table 33: continued

Subject Eye	No.	Visit	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
13	7	0	1.12	1.42	1.00	0.85	1.03	1.02	0.83	0.82	1.08	1.27
		1	1.08	1.07	1.03	0.87	1.10	1.15	0.77	0.65	1.03	1.03
		2	0.92	1.32	0.80	0.72	1.13	1.00	0.72	0.63	1.15	1.23
		3	1.20	1.25	1.10	0.75	1.25	1.08	0.73	0.65	1.13	1.40
		4	1.42	1.43	0.95	0.75	1.20	1.20	0.70	0.68	1.30	1.40
		5	2.10	2.28	0.98	0.80	2.00	1.37	0.77	0.75	2.43	2.32
		6	2.42	2.38	1.18	0.78	2.23	1.60	0.67	0.60	2.35	2.50
14	7	0	1.23	1.33	0.98	0.87	1.10	1.13	0.85	0.82	1.17	1.23
		1	1.23	1.28	0.90	0.83	1.23	0.95	0.87	0.73	1.17	1.27
		2	1.32	1.15	0.98	0.73	1.15	0.97	0.75	0.65	1.12	1.23
		3	1.45	1.58	0.75	0.77	1.47	0.97	0.67	0.65	1.13	1.48
		4	1.60	1.72	0.90	0.65	1.35	1.15	0.68	0.65	1.58	1.68
		5	2.30	2.48	0.90	0.70	2.32	1.43	0.77	0.75	2.43	2.45
		6	2.37	2.35	1.20	0.90	2.38	1.30	0.75	0.85	2.40	2.43
15	8	0	1.13	1.10	0.95	0.87	0.73	0.62	0.63	0.63	0.97	1.00
		1	0.62	0.52	0.88	0.82	0.73	0.83	0.75	0.62	0.67	0.65
		2	0.85	1.12	0.93	0.72	0.88	1.07	0.65	0.67	0.90	1.02
		3	1.67	1.45	1.55	0.85	1.55	1.60	0.72	0.75	1.38	1.50
		4	1.72	1.63	1.12	0.80	1.43	1.37	0.77	0.80	1.67	1.72
		5	1.67	1.50	1.12	0.95	1.30	1.22	0.78	0.72	1.48	1.48
		6	2.02	1.97	2.20	1.33	1.80	1.67	1.02	0.82	2.20	1.95
16	9	0	1.08	1.00	1.27	1.17	1.12	0.98	1.02	0.88	0.92	1.12
		1	0.72	0.80	0.65	0.70	0.93	0.75	0.67	0.62	0.77	0.70
		2	0.92	1.03	0.67	0.58	0.83	0.67	0.60	0.55	0.75	0.82
		3	0.98	0.97	0.65	0.62	0.88	0.72	0.58	0.60	0.83	0.90
		4	0.95	0.82	0.73	0.82	0.87	0.78	0.68	0.65	0.98	1.03
		5	1.85	2.02	0.78	0.75	1.55	1.40	0.67	0.67	1.50	1.83
		6	1.93	1.92	1.68	0.90	1.27	0.97	0.88	0.95	1.73	1.60
17	9	0	0.77	0.90	0.75	0.80	0.73	0.78	0.67	0.73	0.70	0.75
		1	0.67	0.70	0.70	0.72	0.72	0.80	0.75	0.65	0.67	0.75
		2	0.87	0.82	0.68	0.68	0.83	0.75	0.68	0.63	0.68	0.77
		3	0.82	0.70	0.78	0.73	0.85	0.73	0.72	0.60	0.78	0.82
		4	0.83	1.17	0.82	0.80	0.92	0.95	0.77	0.67	0.77	0.87
		5	1.18	1.53	0.97	0.83	1.42	1.38	0.70	0.68	1.18	1.53
		6	1.23	1.35	1.50	1.25	1.27	1.27	0.88	0.85	1.42	1.30
18	10	0	1.57	1.67	1.48	1.17	1.50	1.45	1.02	0.90	1.73	1.60
		1	-	-	-	-	-	-	-	-	-	-
		2	1.52	1.45	1.60	1.13	1.47	1.43	0.90	0.92	1.38	1.35
		3	1.42	1.60	1.43	1.27	1.43	1.40	0.97	0.87	1.42	1.33
		4	1.47	1.47	1.85	1.38	1.63	1.55	1.20	1.03	1.70	1.55
		5	1.48	1.55	1.45	1.17	1.72	1.50	0.93	0.88	1.43	1.60
		6	1.57	1.50	1.50	1.03	1.57	1.43	0.95	0.90	1.37	1.58

Table 33: continued

Subject			STIMULUS NO.								
Eye	No.	Visit	0	1	2	3	4	5	6	7	8	9
19	10	0	1.82	1.65	1.72	1.32	1.72	1.40	1.03	0.92	1.65	1.57
		1	-	-	-	-	-	-	-	-	-	-
		2	1.37	1.40	1.62	1.10	1.47	1.25	0.90	0.83	1.33	1.63
		3	1.45	1.70	1.70	1.40	1.55	1.52	0.97	0.90	1.45	1.77
		4	1.57	1.42	1.77	1.33	1.53	1.50	1.12	1.03	1.52	1.48
		5	1.55	1.52	1.65	1.28	1.52	1.45	0.95	0.95	1.58	1.53
		6	1.38	1.57	1.42	0.95	1.27	1.35	0.97	0.92	1.55	1.67
20	11	0	1.42	1.27	1.05	0.72	1.05	0.85	0.77	0.67	1.37	1.37
		1	1.40	1.12	0.93	0.78	0.88	0.90	0.67	0.63	1.30	1.10
		2	1.08	1.05	0.75	0.73	1.00	0.95	0.68	0.62	1.12	1.05
		3	1.45	1.28	0.83	0.70	1.17	0.90	0.67	0.63	1.38	1.22
		4	1.12	1.00	0.88	0.95	1.13	0.92	0.77	0.68	1.00	0.98
		5	0.95	1.05	1.08	0.82	1.02	1.08	0.68	0.62	0.88	0.98
		6	1.45	1.48	0.83	0.85	1.20	0.97	0.78	0.73	1.23	1.20
21	11	0	1.47	1.33	0.97	0.72	0.93	0.92	0.75	0.65	1.27	1.25
		1	1.07	1.08	1.00	0.67	0.92	0.87	0.67	0.65	0.92	0.98
		2	0.95	0.98	1.05	0.92	0.95	0.95	0.78	0.70	0.98	0.92
		3	0.98	1.13	0.88	0.85	1.07	0.90	0.80	0.68	0.93	1.12
		4	0.73	0.80	1.13	0.82	0.93	0.95	0.75	0.73	0.72	0.90
		5	0.93	0.98	0.93	0.82	1.05	0.98	0.68	0.62	0.88	0.90
		6	1.38	1.47	1.18	0.97	1.22	0.98	0.80	0.77	1.32	1.55
22	12	0	1.40	1.23	0.87	0.93	1.13	1.13	0.77	0.70	1.13	1.27
		1	1.03	1.20	1.07	0.80	1.10	1.17	0.87	0.63	1.30	1.00
		2	1.18	1.33	1.50	1.02	1.12	1.23	0.72	0.67	0.97	1.25
		3	1.47	1.60	0.97	0.67	1.30	1.07	0.67	0.58	1.50	1.62
		4	1.27	1.23	0.92	0.82	1.37	1.22	0.68	0.65	1.38	1.48
		5	1.33	1.30	0.97	0.75	1.37	1.38	0.70	0.57	1.15	1.20
		6	-	-	-	-	-	-	-	-	-	-
23	13	0	1.28	0.98	1.03	0.90	0.93	0.97	0.82	0.75	1.17	0.92
		1	0.85	0.80	1.22	0.72	1.00	0.85	0.77	0.65	0.83	0.88
		2	0.85	0.87	0.83	0.80	1.03	1.15	0.75	0.67	0.90	0.98
		3	0.98	0.97	0.92	0.80	1.25	1.05	0.72	0.80	1.10	1.08
		4	1.15	1.05	0.90	0.88	1.13	0.82	0.77	0.75	1.12	1.18
		5	0.82	1.05	0.88	0.85	1.13	1.07	0.78	0.75	0.92	0.92
		6	0.95	1.12	1.15	0.97	1.47	1.27	0.90	0.88	1.17	1.10
24	13	0	0.82	0.95	1.05	0.68	1.08	0.85	0.68	0.78	0.92	0.85
		1	0.97	0.87	0.83	0.80	0.95	0.90	0.72	0.78	0.95	0.98
		2	1.17	1.10	1.12	0.85	1.17	0.92	0.85	0.82	1.23	1.18
		3	1.23	1.12	0.95	0.75	1.18	1.07	0.78	0.70	1.07	1.07
		4	1.13	1.03	1.12	0.80	1.08	0.97	0.90	0.78	0.98	0.97
		5	0.73	0.85	0.83	0.82	0.85	0.83	0.82	0.78	0.78	0.87
		6	1.12	0.98	1.10	0.92	1.35	1.27	0.92	0.70	0.90	0.98

Table 33: continued

Subject			STIMULUS NO.									
Eye	No.	Visit	0	1	2	3	4	5	6	7	8	.9
25	14	0	1.35	1.12	1.22	1.05	1.28	1.02	0.90	0.85	1.27	1.25
		1	1.05	1.07	1.33	0.88	0.90	0.95	0.88	0.82	1.07	1.00
		2	1.13	1.03	0.98	0.88	0.98	0.88	0.85	0.78	1.10	0.98
		3	0.98	1.02	0.87	0.88	0.98	0.93	0.83	0.80	1.02	0.97
		4	0.97	0.97	0.97	0.85	0.97	0.92	0.82	0.77	1.05	0.93
		5	1.17	1.22	0.98	0.88	1.13	1.03	0.88	0.80	1.22	1.22
		6	1.25	1.22	1.15	0.98	1.28	1.18	0.88	0.80	1.30	1.37
26	14	0	1.15	1.02	0.93	0.83	0.93	0.92	0.82	0.78	1.00	0.95
		1	0.88	0.97	0.95	0.85	0.98	0.92	0.82	0.78	0.88	0.90
		2	0.90	1.07	0.92	0.87	1.12	1.27	0.90	0.85	1.07	1.08
		3	0.85	0.87	0.95	0.87	0.97	1.03	0.72	0.73	0.93	0.97
		4	0.97	1.03	0.85	0.88	0.98	1.13	0.83	0.80	0.97	1.05
		5	1.07	1.37	1.25	0.85	1.30	1.00	0.83	0.82	1.18	1.23
		6	1.03	1.22	1.17	0.95	1.23	1.18	0.87	0.80	1.17	1.05
27	15	0	1.05	1.17	1.40	1.03	1.20	1.25	0.90	0.78	1.17	1.22
		1	1.10	1.17	1.15	0.87	1.20	1.15	0.73	0.73	1.03	1.15
		2	1.18	1.30	1.05	0.87	1.38	1.18	0.87	0.82	1.17	1.18
		3	1.72	1.50	0.93	0.88	1.60	1.12	0.88	0.87	1.33	1.60
		4	1.65	1.68	1.25	0.87	1.42	1.28	0.92	0.82	1.55	1.53
		5	1.42	1.67	1.37	0.95	1.45	1.48	0.88	0.85	1.37	1.75
		6	1.40	1.90	1.03	0.96	1.72	1.45	0.75	0.72	1.33	1.57
28	15	0	0.83	0.87	1.13	1.02	0.92	1.17	0.93	0.73	0.95	0.87
		1	1.17	1.42	1.00	0.93	1.35	1.40	0.87	0.80	0.87	1.37
		2	1.25	1.30	1.00	0.98	1.33	1.37	0.88	0.83	1.25	1.33
		3	1.18	1.52	0.97	0.98	1.28	1.22	0.87	0.83	1.13	1.35
		4	1.37	1.73	1.27	1.08	1.57	1.45	0.92	0.77	1.50	1.50
		5	1.73	1.67	1.65	1.23	1.72	1.58	0.87	0.78	1.72	1.53
		6	1.52	1.85	1.75	0.87	1.57	1.52	0.80	0.78	1.38	1.62
29	16	0	0.98	1.10	1.33	0.97	1.25	1.40	0.93	0.68	1.33	1.12
		1	1.02	1.10	0.85	0.72	1.02	1.27	0.78	0.78	1.12	1.00
		2	0.90	0.82	0.97	0.77	1.20	1.12	0.88	0.67	1.07	1.00
		3	1.40	1.18	1.05	0.72	1.22	1.08	0.77	0.70	1.23	1.02
		4	0.88	1.32	0.93	0.72	1.32	1.30	0.75	0.67	1.30	1.10
		5	1.83	1.73	1.28	1.05	1.47	1.32	1.03	0.87	1.63	1.93
		6	1.23	1.33	1.08	1.02	1.42	1.08	0.88	0.87	1.75	1.48
30	16	0	0.73	1.12	0.92	0.77	1.07	1.27	0.77	0.73	1.07	1.22
		1	0.83	0.85	1.20	0.83	0.88	0.98	0.68	0.67	1.03	0.90
		2	1.13	1.15	1.12	0.85	1.18	1.33	0.82	0.77	1.10	1.23
		3	1.48	1.03	1.12	0.72	1.37	1.77	0.95	0.92	1.35	1.15
		4	1.13	1.27	1.08	0.80	1.10	1.22	0.62	0.70	1.32	1.15
		5	-	-	-	-	-	-	-	-	-	-
		6	1.42	1.58	0.98	0.95	1.70	1.73	0.92	0.88	1.43	1.93

Table 33: continued

Subject			STIMULUS NO.									
Eye	No.	Visit	0	1	2	3	4	5	6	7	8	9
31	17	0	0.85	0.88	0.97	0.87	1.00	0.93	0.77	0.80	1.13	1.07
		1	1.13	1.12	1.10	0.88	1.23	1.10	0.90	0.82	1.08	1.23
		2	0.95	1.10	0.92	0.87	1.13	0.87	0.75	0.85	1.02	1.13
		3	1.15	1.37	0.80	0.78	1.38	1.03	0.80	0.78	1.15	1.23
		4	1.02	1.18	0.92	0.85	1.28	0.92	0.83	0.80	0.93	1.30
		5	0.98	1.18	0.77	0.87	1.20	0.85	0.75	0.72	1.10	1.05
		6	1.32	1.35	0.90	0.92	1.20	1.00	0.78	0.78	1.20	1.30
32	17	0	1.03	0.87	1.12	0.77	1.17	1.13	0.87	0.85	0.98	1.03
		1	0.92	0.97	1.07	0.87	1.17	1.02	0.78	0.80	1.02	1.05
		2	0.98	1.18	0.97	0.80	1.18	0.97	0.77	0.78	1.03	1.02
		3	1.27	1.57	0.95	0.83	1.50	1.18	0.82	0.82	1.33	1.22
		4	0.93	0.95	0.87	0.73	1.07	0.82	0.75	0.68	1.00	1.02
		5	0.92	1.12	0.80	0.75	1.12	0.75	0.73	0.70	0.90	1.00
		6	1.07	1.13	0.85	0.78	0.95	1.00	0.77	0.73	1.30	1.25
33	18	0	1.60	1.42	1.28	0.93	1.60	1.52	0.80	0.75	1.37	1.77
		1	1.60	1.42	0.93	0.78	1.20	0.98	0.63	0.62	1.07	1.37
		2	1.72	1.75	0.80	0.78	1.45	1.18	0.67	0.62	1.62	1.67
		3	1.87	1.55	0.73	0.72	1.38	0.92	0.63	0.57	1.45	1.55
		4	1.90	1.92	0.80	0.82	1.63	1.47	0.62	0.63	1.62	1.63
		5	1.62	1.63	1.02	0.93	1.58	1.37	0.78	0.70	1.47	1.72
		6	2.38	2.25	1.75	1.10	2.13	1.82	0.87	0.72	2.30	2.32
34	18	0	1.42	1.23	1.00	0.85	1.23	1.17	0.85	0.55	1.27	1.35
		1	1.57	1.52	0.85	0.85	1.28	1.13	0.62	0.57	1.35	1.40
		2	1.33	1.55	1.23	0.70	1.52	1.27	0.65	0.68	1.52	1.72
		3	1.58	1.55	1.08	0.92	1.38	1.28	0.67	0.65	1.82	1.67
		4	1.93	2.02	1.47	0.87	1.70	1.62	0.90	0.65	1.58	1.65
		5	1.68	1.75	1.33	1.05	1.57	1.37	0.80	0.70	1.72	1.67
		6	2.33	2.35	1.12	0.97	1.67	1.32	0.75	0.78	2.32	2.22
35	19	0	0.98	0.95	0.68	0.65	1.00	0.88	0.63	0.52	0.93	1.03
		1	0.88	0.95	0.67	0.63	0.85	0.78	0.65	0.55	0.78	0.87
		2	1.05	1.05	0.85	0.83	1.15	0.83	0.78	0.70	1.05	1.25
		3	1.05	1.08	0.90	0.77	1.02	0.92	0.75	0.73	1.12	1.15
		4	1.33	1.13	0.87	0.78	1.32	1.20	0.72	0.75	1.12	1.22
		5	1.13	1.28	1.03	0.83	1.15	1.17	0.80	0.75	1.15	1.10
		6	1.33	1.38	1.08	1.17	1.20	1.37	0.90	0.87	0.98	1.15
36	19	0	0.77	0.60	0.68	0.68	0.92	0.85	0.55	0.58	0.75	0.93
		1	0.82	0.95	0.85	0.72	1.02	0.87	0.60	0.62	0.82	1.02
		2	1.02	0.98	0.88	0.82	1.25	0.98	0.77	0.77	0.97	1.25
		3	1.27	1.35	0.88	0.78	1.30	1.02	0.83	0.78	1.17	1.13
		4	1.33	1.30	1.00	0.82	1.28	1.17	0.78	0.78	1.28	1.40
		5	1.05	1.25	1.10	0.88	1.25	1.10	0.88	0.80	1.23	1.30
		6	1.10	1.20	1.02	1.02	1.25	1.15	0.93	0.97	1.05	1.23

Table 33: continued

Subject Eye	No.	Visit	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
37	20	0	1.27	1.07	1.20	0.87	1.40	1.00	0.82	0.80	1.02	1.17
		1	1.20	1.25	0.90	0.82	0.93	1.10	0.73	0.73	0.85	1.03
		2	0.98	0.97	1.10	0.73	0.85	0.77	0.67	0.70	0.85	0.98
		3	1.03	0.97	1.07	0.83	1.00	1.03	0.77	0.87	0.78	1.10
		4	1.02	1.02	1.07	0.78	0.98	1.02	0.78	0.73	0.93	1.08
		5	0.95	0.95	0.92	0.80	0.95	0.95	0.78	0.70	0.90	0.98
		6	1.28	1.38	0.88	0.88	1.23	1.07	0.72	0.77	1.13	1.10
38	20	0	1.23	1.13	0.97	0.75	0.95	0.85	0.72	0.63	1.03	1.28
		1	1.30	1.38	1.25	0.83	1.27	1.17	0.75	0.73	0.83	1.15
		2	1.18	1.02	0.70	0.77	0.92	0.93	0.75	0.72	0.93	1.07
		3	0.83	0.90	0.88	0.83	0.87	0.98	0.80	0.78	0.80	1.00
		4	1.07	1.13	0.98	0.83	1.13	1.02	0.77	0.70	0.82	1.05
		5	0.97	1.13	0.85	0.80	1.25	1.10	0.70	0.67	0.78	1.17
		6	1.15	1.18	0.85	0.72	1.03	0.98	0.75	0.73	1.08	1.00
39	21	0	1.12	1.27	1.15	1.02	1.35	1.20	1.08	0.88	1.05	1.12
		1	1.40	1.45	1.12	0.87	1.23	1.17	0.85	0.85	1.23	1.47
		2	1.47	1.53	0.92	0.85	1.40	0.98	0.87	0.75	1.52	1.28
		3	1.32	1.50	1.08	0.92	1.38	1.40	0.87	0.83	1.50	1.48
		4	1.03	1.40	1.28	1.00	1.33	1.27	0.98	0.90	1.57	1.05
		5	1.47	1.60	1.03	0.97	1.57	1.32	0.92	0.80	1.57	1.28
		6	1.43	1.48	1.10	0.88	1.35	1.10	0.93	0.95	1.40	1.32
40	21	0	1.37	1.07	0.82	0.93	1.08	1.20	0.87	0.82	1.27	1.35
		1	1.57	1.23	0.88	0.92	1.15	1.02	0.82	0.72	1.50	1.53
		2	1.55	1.40	0.88	0.78	1.33	1.35	0.77	0.75	1.67	1.45
		3	1.50	1.37	0.95	0.93	1.22	0.98	0.85	0.83	1.57	1.60
		4	1.32	1.37	0.98	0.88	1.43	1.07	0.82	0.75	1.30	1.32
		5	1.20	1.42	1.22	1.05	1.88	1.20	0.97	0.93	1.32	1.22
		6	1.50	1.33	0.97	0.87	1.37	0.95	0.88	0.95	1.45	1.42
41	22	0	1.62	1.33	1.08	0.87	1.37	1.22	0.78	0.78	1.48	1.53
		1	1.07	0.90	0.87	0.93	1.10	1.00	0.68	0.60	1.10	1.10
		2	1.08	1.15	0.90	0.73	1.10	1.00	0.63	0.70	1.03	1.27
		3	1.18	1.32	0.97	0.82	1.48	1.10	0.68	0.63	1.38	1.37
		4	1.27	1.03	0.92	0.68	1.17	1.18	0.62	0.60	1.22	1.13
		5	1.27	1.12	0.95	0.83	1.55	1.22	0.73	0.72	1.32	1.07
		6	0.90	1.00	0.83	0.80	1.17	1.20	0.65	0.63	0.97	0.78
42	23	0	0.78	0.80	0.77	0.77	0.88	0.77	0.77	0.67	0.70	0.75
		1	0.93	0.90	0.78	0.83	1.08	0.95	0.68	0.68	0.85	0.93
		2	0.85	0.68	0.68	0.65	0.72	0.62	0.58	0.58	0.58	0.77
		3	0.77	0.68	0.85	0.65	0.83	0.77	0.70	0.65	0.72	0.83
		4	0.78	0.78	0.78	0.67	0.87	0.95	0.63	0.58	0.80	0.88
		5	0.67	0.72	0.70	0.68	0.90	0.80	0.60	0.62	0.72	0.67
		6	0.95	0.90	0.73	0.78	0.85	0.73	0.58	0.63	0.93	0.90

Table 33: continued

Subject Eye No.		Visit	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
43	23	0	0.87	0.83	1.03	0.78	1.03	0.95	0.75	0.75	0.85	0.83
		1	0.75	0.73	0.85	0.73	1.00	0.85	0.63	0.65	1.03	0.85
		2	0.82	0.62	0.78	0.82	0.83	0.73	0.68	0.67	0.67	0.63
		3	0.90	0.82	0.78	0.73	0.90	0.77	0.70	0.70	0.87	0.97
		4	0.82	1.00	0.70	0.75	0.90	0.72	0.68	0.73	0.72	0.90
		5	0.67	0.75	0.60	0.62	0.77	0.68	0.58	0.55	0.62	0.70
		6	0.88	0.87	0.75	0.60	1.00	0.92	0.65	0.58	0.82	1.03
44	24	0	1.50	1.48	1.15	1.03	1.25	1.12	0.88	0.75	1.27	1.38
		1	1.25	1.23	0.97	0.80	1.25	1.00	0.80	0.70	1.12	1.42
		2	1.20	1.18	0.87	0.75	1.12	1.02	0.73	0.73	1.13	1.37
		3	0.93	1.22	0.90	0.83	1.12	0.97	0.67	0.68	0.97	1.27
		4	1.25	1.30	0.83	0.77	1.15	1.03	0.75	0.72	0.90	1.42
		5	1.27	1.28	1.00	0.83	1.17	1.07	0.77	0.80	1.17	1.32
		6	1.23	1.28	0.88	0.82	1.17	1.02	0.77	0.75	1.20	1.20
45	25	0	0.88	0.95	1.10	0.85	1.00	1.10	0.82	0.75	0.90	1.13
		1	1.42	1.30	1.13	1.02	1.40	1.37	0.93	0.88	1.43	1.38
		2	1.25	1.30	0.98	1.07	1.28	1.18	0.97	0.82	1.43	1.30
		3	1.13	1.22	1.20	0.92	1.30	0.88	0.80	0.83	1.37	1.43
		4	1.15	0.97	1.00	0.85	1.25	1.03	0.75	0.78	1.27	1.18
		5	1.10	1.23	1.03	0.95	1.28	1.02	0.87	0.88	1.20	1.28
		6	0.87	0.85	0.92	0.83	1.13	0.98	0.78	0.77	0.90	1.15
46	25	0	0.87	0.82	1.00	0.90	1.13	0.93	0.87	0.78	0.97	1.03
		1	1.22	1.28	1.57	1.15	1.22	1.28	0.92	0.93	1.50	1.43
		2	0.97	1.15	1.27	1.05	1.43	1.23	0.92	0.82	1.52	1.03
		3	0.88	0.97	1.22	1.08	1.13	1.17	0.92	0.80	0.95	1.05
		4	0.87	1.07	1.22	1.07	1.42	1.00	0.83	0.83	1.00	1.03
		5	0.95	1.07	1.08	0.93	1.20	1.13	0.87	0.85	1.05	1.27
		6	0.83	0.90	1.00	0.90	1.10	0.97	0.87	0.77	0.87	0.97
47	26	0	1.43	1.22	1.47	1.07	1.32	1.10	0.88	0.83	1.42	1.52
		1	1.10	1.33	1.20	0.92	1.27	1.12	0.85	0.78	1.17	1.30
		2	0.97	1.47	1.00	0.95	1.32	0.98	0.80	0.77	1.17	1.37
		3	1.37	1.47	1.03	0.82	1.43	0.97	0.83	0.82	1.02	1.50
		4	1.40	1.35	1.17	0.85	1.27	1.12	0.83	0.73	1.42	1.30
		5	1.55	1.25	1.08	0.80	1.15	1.03	0.77	0.72	1.18	1.18
		6	1.60	1.78	0.82	1.05	1.25	1.00	0.68	0.72	1.65	1.90
48	26	0	1.30	1.27	1.72	1.32	1.28	1.28	0.95	0.83	1.45	1.40
		1	1.18	1.28	0.93	0.80	1.25	1.02	0.73	0.68	1.03	1.47
		2	1.28	1.25	0.97	0.85	1.20	0.98	0.85	0.75	1.18	1.13
		3	1.38	1.60	0.95	0.85	1.55	1.13	0.75	0.73	1.30	1.23
		4	1.32	1.23	0.98	0.92	1.35	1.00	0.75	0.63	1.22	1.25
		5	1.38	1.35	0.88	0.87	1.28	1.20	0.90	0.68	1.27	1.52
		6	1.72	1.63	1.20	1.20	1.13	0.95	0.78	0.70	1.73	1.63

Table 33: continued

Subject			STIMULUS NO.									
Eye	No.	Visit	0	1	2	3	4	5	6	7	8	9
49	27	0	1.03	1.10	1.12	1.17	1.08	1.15	0.90	0.88	1.07	1.07
		1	1.03	1.00	0.95	0.92	0.97	0.93	0.78	0.78	0.95	1.00
		2	1.13	0.95	1.02	0.83	0.97	0.98	0.78	0.78	0.95	1.05
		3	1.00	1.05	1.00	0.78	1.00	1.08	0.73	0.68	1.03	0.95
		4	1.03	1.08	0.95	0.75	0.97	0.92	0.77	0.65	1.10	0.95
		5	1.50	1.22	0.93	0.77	1.08	1.03	0.75	0.70	1.32	1.32
		6	-	-	-	-	-	-	-	-	-	-
50	27	0	1.02	1.13	0.97	0.92	1.27	1.08	0.87	0.80	0.97	0.98
		1	0.93	0.98	0.93	0.83	0.92	0.83	0.78	0.72	0.98	0.98
		2	1.23	1.08	0.95	0.95	1.20	1.07	0.80	0.77	1.15	1.12
		3	0.87	0.88	0.87	0.80	0.92	0.88	0.75	0.73	0.88	0.87
		4	1.08	0.95	0.93	0.85	0.97	0.93	0.68	0.63	1.00	0.92
		5	1.27	1.22	1.15	0.88	1.18	1.10	0.73	0.75	1.40	1.33
		6	-	-	-	-	-	-	-	-	-	-

Table 34 : STUDY NO. 4 - Eye-blink activity of subjects (unit of measurement : blinks s^{-1}): three-phase recording - (a) at REFIX, during the steady viewing phase following the refixation movement back to the peripheral fixation point; (b) at ON, during the steady viewing phase when the TV stimulus is being presented to the subject; (c) at OFF, during the phase immediately following a response, when the TV stimulus is extinguished and the subject is making an eye movement back to the peripheral fixation point. The data presented under 'a', 'b', 'c' are mean results as per the validated 20% data sampling procedure (TABLE 38C: pages 417 - 425), over three identical runs at selected control settings of the TV system.

(Checklist of TV system control settings: APPENDIX XIIID: page 504).

N = 50 eyes.

Table 34

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	1	0	a	0.30	0	0.30	0.15	0.15	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.45	0	0.22	0.78	0.22	0.33	0.22	0.22	0.22
		1	a	0	0	0	0	0.15	0	0	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.33	0.45	0.33	0.45	0.22	0.45	0.56	0.33	0.22
		2	a	0	0	0	0	0	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.56	0.67	0.67	0.67	0.56	0.45	0.67	0.67	0.67
		3	a	0	0.15	0.15	0.15	0.30	0	0.15	0	0	0.15
			b	0	0	0.38	0	0.34	0.17	0	0.24	0.38	0
			c	0.56	0.67	0.67	0.89	0.67	0.33	0.33	0.22	0.45	0.67
		4	a	0.30	0	0.15	0.30	0	0.46	0.30	0	0.15	0.30
			b	0	0	0.17	0.21	0	0.15	0	0	0.33	0
			c	0.45	0.45	0.33	0.56	0.45	0.33	0.22	0.45	0.45	0.56
		5	a	0	0.15	0	0	0	0.46	0	0	0.30	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.33	0.33	0	0.56	0	0	0.11	0.22	0.45
		6	a	0	0	0.30	0	0.15	0	0.15	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.11	0.22	0.11	0.45	0.22	0.11	0.33	0.22	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
2	1	0	a	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.30	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0	0	0	0	0.11	0.22	0.11	0
		1	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		2	a	0	0	0.15	0	0.15	0	0	0	0	0
			b	0	0.28	0	0	0	0	0	0	0	0
			c	0.67	0.56	0.33	0.22	0.11	0.22	0.56	0.56	0.67	0.22
		3	a	0.15	0.15	0	0	0.15	0.15	0	0.15	0	0.15
			b	0	0	0.19	0	0	0	0	0	0.24	0
			c	0.22	0.33	0.45	0.11	0.22	0.45	0.11	0.22	0.22	0.22
		4	a	0	0	0.15	0.15	0	0	0	0	0.15	0
			b	0	0.15	0	0	0	0	0	0	0	0.15
			c	0.33	0.33	0.33	0.56	0.56	0.33	0.33	0.33	0.11	0.33
		5	a	0	0.30	0	0	0	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0	0.22	0.11	0.33	0.22	0	0	0.56	0.22
		6	a	0.30	0.15	0.30	0.15	0.30	0	0	0.15	0.61	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.33	0.33	0	0.11	0	0.22	0.11	0.11	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
3	2	0	a	0.30	0	0.15	0.15	0	0.15	0.15	0.15	0.15	0.30
			b	0	0	0.11	0	0	0.17	0	0	0	0
			c	0.33	0.33	0.45	0.22	0.33	0.33	0.56	0.45	0.33	0.45
		1	a	0.61	0.61	0.61	0.91	0.61	0.46	0.61	0.46	0.91	0.91
			b	0.09	0	0	0.15	0	0	0	0	0	0
			c	0.78	0.67	0.89	0.78	1.00	0.56	0.56	0.67	0.67	0.56
		2	a	0.76	0.61	0.76	0.61	0.61	0.61	0.91	1.06	0.61	0.61
			b	0	0.14	0.17	0.15	0	0	0.17	0	0.29	0
			c	0.45	0.56	0.56	0.56	0.56	0.56	0	0.45	0.45	0.33
		3	a	0.91	0.56	0.76	0.56	0.46	0.91	0.61	0.61	0.76	0.61
			b	0	0	0	0	0	0	0	0.32	0	0
			c	0.22	0.33	0.56	0.33	0.45	0.56	0.56	0.33	0.33	0.45
		4	a	0.30	0.46	0.46	0.15	0.46	0.30	0.15	0.56	0.61	0.61
			b	0	0	0	0.11	0	0	0.14	0	0.19	0.13
			c	0.56	0.45	0.22	0.33	0.56	0.22	0.22	0.22	0.22	0
		5	a	0.15	0.61	0.76	0.15	0.15	0.76	0.30	0.15	0.61	0.76
			b	0	0	0	0	0	0.09	0	0	0	0
			c	0.45	0.56	0.45	0.67	0.67	0.22	0.45	0.45	0.22	0.45
		6	a	0.76	0.46	0	0.46	0.30	0.61	0.46	0.30	0.15	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.33	0.45	0.11	0.11	0.22	0.33	0.11	0.33	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
4	2	0	a	0.15	0.15	0	0	0	0	0	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.22	0.22	0.45	0.22	0.33	0.11	0.11	0.11	0.33
		1	a	0.30	0.61	0.46	0.61	0.61	0.46	0.46	0.30	0.61	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	1.33	0.78	1.00	0.45	0.67	0.67	0.67	0.56	0.78	0.45
		2	a	0.46	0.76	0.76	0.46	0.30	0.61	0.46	0.61	0.61	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.67	0.56	0.33	0.67	0.46	0.11	0.56	0.45	0.78
		3	a	0.46	0.46	0.46	0.61	0.76	0.46	0.30	0.15	0.15	0.30
			b	0	0	0.09	0	0	0	0	0	0	0
			c	0.78	0.89	0.67	0.67	0.78	0.56	0.67	0.56	0.78	1.00
		4	a	0.46	0.30	0.30	0.30	0.30	0.46	0	0.30	0.46	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.78	0.22	0.33	0.45	0.56	0.11	0.45	0.56	0.56
		5	a	0.30	0.30	0	0	0	0	0.15	0	0.15	0.15
			b	0	0	0	0.17	0	0	0	0	0	0
			c	0.45	0.22	0.56	0.33	0.78	0.45	0.45	0.22	0.45	0.67
		6	a	0.15	0.15	0.30	0.30	0.15	0.15	0.46	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.56	0.45	0.11	0.56	0.33	0.11	0.11	0.45	0.22

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
5	3	0	a	0.91	0.46	0.46	0.15	0.61	0.76	0.61	0.61	0.76	0.46
			b	0	0.10	0.31	0.13	0	0	0.12	0.11	0	0
			c	0.33	0.67	0.33	0.33	0.45	0.33	0.22	0.22	0.45	0.22
		1	a	0.30	0.61	0.61	0.46	0.61	0.76	0.46	0.76	0.76	0.76
			b	0.34	0.23	0.11	0.16	0.44	0.23	0.14	0.25	0.26	0.17
			c	0.33	0.45	0.67	0.67	0.67	0.56	0.67	0.56	0.56	0.67
		2	a	0.61	0.91	0.61	0.91	0.76	0.91	0.91	0.91	0.61	0.91
			b	0.14	0.21	0.08	0	0.11	0	0	0	0	0.17
			c	0.56	0.67	0.45	0.56	0.56	0.67	0.56	0.33	0.89	0.67
		3	a	0.91	0.61	0.76	0.76	1.06	0.91	0.76	0.91	0.76	0.91
			b	0.27	0.30	0.21	0.08	0.14	0.07	0.15	0	0.26	0
			c	1.11	0.45	0.56	0.67	0.89	0.78	0.78	0.56	0.56	0.67
		4	a	0.76	0.91	0.76	0.91	0.91	0.91	0.91	0.61	0.76	0.91
			b	0.09	0.11	0.16	0	0	0	0	0.21	0.11	0
			c	0.56	0.56	0.78	0.56	0.67	0.45	0.45	0.56	0.45	0.45
		5	a	0.91	0.91	0.91	0.91	0.91	0.91	0.78	0.76	0.56	0.91
			b	0.14	0	0.07	0	0	0	0	0	0	0
			c	0.56	0.33	0.67	0.67	0.89	0.45	0.33	0.45	0.33	0.56
		6	a	0.91	0.91	0.91	1.21	0.91	0.91	0.91	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.56	0.56	0.56	0.67	0.45	0.56	0.67	0.45	0.56

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
6	3	0	a	0.61	0.46	0.76	0.91	0.61	0.46	0.30	0.61	0.30	0.30
			b	0	0.11	0	0	0.25	0.07	0.11	0.12	0.14	0
			c	0.22	0.33	0.45	0.56	0.11	0.22	0.33	0.22	0.33	0.22
		1	a	0.61	0.61	0.15	0.76	0.61	0.91	0.61	0.91	0.91	0.91
			b	0.09	0.18	0.42	0.19	0.42	0	0.38	0	0.24	0
			c	0.33	0.22	0.33	0.33	0.45	0.22	0.22	0.22	0.33	0.33
		2	a	0.91	0.91	0.91	0.91	0.46	0.61	0.91	0.91	0.91	0.76
			b	0	0	0	0	0	0.14	0	0	0	0
			c	0.45	0.67	0.56	0.45	0.67	0.56	0.78	0.45	0.67	0.33
		3	a	0.76	1.06	1.21	0.76	0.91	0.91	0.91	0.91	0.91	0.91
			b	0.11	0	0	0	0	0	0	0	0	0.15
			c	0.78	0.78	0.67	0.67	0.67	0.56	0.67	0.67	0.56	0.78
		4	a	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.76
			b	0	0	0	0	0	0.15	0	0	0	0
			c	0.45	0.56	0.45	0.33	0.67	0.45	0.45	0.56	0.45	0.45
		5	a	0.76	0.76	0.91	0.91	0.76	0.76	0.91	0.91	0.91	0.91
			b	0	0.13	0.07	0	0	0	0	0	0	0
			c	0.11	0.67	0.33	0.45	0.56	0.22	0	0	0.45	0.56
		6	a	0.46	0.76	0.76	0.76	1.06	1.06	0.61	0.76	0.61	0.76
			b	0	0	0	0	0	0.14	0	0	0	0
			c	0.22	0.56	0.22	0.33	0.56	0.67	0.22	0.33	0.33	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
7	4	0	a	0	0	0	0	0	0	0	0	0.15	0
			b	0.39	0.07	0.32	0.19	0.18	0.25	0	0	0.41	0.29
			c	0	0	0	0	0	0	0	0	0	0
		1	a	0	0.15	0.15	0	0.15	0	0	0.15	0.15	0.15
			b	0.55	0.44	0.52	0.15	0.50	0.63	0	0	0.42	0.31
			c	0.22	0	0	0	0	0.11	0.22	0	0	0.33
		2	a	0	0	0	0	0	0	0	0	0	0
			b	0.43	0.44	0.62	0.32	0.47	0.37	0	0	0.58	0.61
			c	0	0	0.22	0.11	0.11	0.11	0.22	0.33	0.11	0.22
		3	a	0	0	0	0	0.15	0.15	0	0	0	0
			b	0.47	0.38	0.69	0.38	0.30	0.50	0.32	0.15	0.32	0.43
			c	0	0	0.11	0.11	0	0	0	0	0	0
		4	a	0.30	0.30	0.30	0.15	0	0.30	0	0.15	0	0
			b	0.42	0.38	0.80	0.21	0.62	0.60	0.39	0.13	0.46	0.37
			c	0.33	0.78	0.33	0.11	0.22	0	0	0.11	0.11	0.56
		5	a	0.15	0.61	0.15	0.46	0.15	0.46	0.15	0	0.15	0
			b	0.26	0.28	0.39	0.24	0.47	0.57	0.33	0.19	0.10	0.20
			c	0.67	0.78	0.45	0.56	1.00	0.67	0.45	0.56	0.67	0.67
		6	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
8	4	0	a	0.15	0.15	0.30	0	0.30	0.46	0.30	0.30	0	0.30
			b	0.26	0.37	0.18	0.21	0.12	0.31	0	0.14	0.34	0.24
			c	0	0	0	0	0	0	0	0	0	0
		1	a	0	0	0	0	0	0.15	0.15	0	0	0.15
			b	1.94	0.28	0.49	0.15	0.51	0.69	0	0	0.21	0.35
			c	0	0	0	0	0.11	0	0	0.11	0.11	0
		2	a	0	0	0	0	0	0	0	0	0	0
			b	0.32	0.21	0.43	0	0.27	0.61	0	0	0.25	0.24
			c	0	0.11	0.11	0.11	0	0.33	0	0	0.11	0
		3	a	0	0	0	0	0	0	0	0	0	0
			b	0.56	0.31	0.76	0.15	0.54	0.51	0.17	0.21	0.43	0.58
			c	0.11	0.11	0	0.22	0	0.11	0.22	0	0	0
		4	a	0	0	0	0	0	0	0	0	0	0
			b	0.75	0.45	0.57	0.29	0.49	0.64	0.58	0	0.41	0.42
			c	0.11	0.22	0.11	0.22	0.33	0.45	0.33	0.11	0.22	0
		5	a	0	0	0	0	0	0	0.15	0	0	0
			b	0.21	0.35	0.35	0.14	0.06	0.43	0.32	0.24	0.23	0.50
			c	0.33	0.11	0	0.11	0.22	0.11	0.11	0.33	0.33	0.33
		6	a	0	0.30	0	0.15	0	0.30	0.46	0.15	0	0.15
			b	0.19	0.25	0.70	0.52	0.55	0.39	0.50	0.17	0.28	0.14
			c	0.67	1.00	0.45	0.56	0.89	0.78	0.67	0.67	1.11	0.67

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
9	5	0	a	1.06	0.76	0.91	0.91	0.91	0.76	0.91	0.91	0.91	0.76
			b	0	0	0	0.19	0	0	0	0	0	0
			c	0.56	0.89	0.67	0.56	0.33	0.67	0.67	0.67	0.33	1.00
		1	a	0.61	0.30	0.46	0.61	0.76	0.61	0.56	0.61	0.46	0.61
			b	0	0	0	0	0	0	0	0.24	0	0
			c	0.89	1.00	0.67	0.56	1.00	0.78	0.67	0.67	0.78	1.00
		2	a	0.91	0.91	0.91	0.91	0.91	0.76	0.91	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.22	0	0.33	0.56	0.22	0.11	0.11	0.22	0
		3	a	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	0.89	0.89	0.56	0.89	1.22	0.67	0.33	0.89	1.22
		4	a	0.91	0.76	0.91	0.61	0.30	0.91	0.91	0.76	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	0.78	0.67	0.78	0.89	0.78	0.56	0.67	0.78	0.89
		5	a	0.61	0.76	0.30	0.30	0.30	0.30	0.30	0.30	0.61	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.45	0.33	0.22	0.56	0.45	0.11	0.67	0.67	0.56
		6	a	0.61	0.91	0.91	0.61	0.56	0.91	0.76	0.91	0.61	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.45	0.33	0.67	0.22	0.45	0.11	0.45	0.45	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
10	5	0	a	0.76	0.61	0.30	0.30	0.61	0.91	0.61	0.61	0.76	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.78	0.45	0.11	0.78	0.67	0.11	0.22	0.78	0.45
		1	a	0.76	0.76	0.91	0.91	0.91	0.91	0.91	0.91	0.61	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.56	0.11	0.33	0.67	0.67	0.45	0.45	0.45	0.22
		2	a	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	1.33	1.67	0.67	0.56	1.79	1.11	0.67	0.33	1.79	1.00
		3	a	0.91	0.61	0.76	0.61	0.76	0.76	0.61	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0	0.33	0.45	0.11	0.45	0.22	0.22	0.45	0.11
		4	a	0.91	0.76	0.76	0.61	0.30	0.61	0.46	0.76	0.91	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	1.00	0.56	0.45	0.33	0.67	0.22	0.45	0.45	0.67	0.78
		5	a	0	0	0.15	0.30	0.30	0.30	0.46	0.30	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.56	0.33	0.22	0.67	0.33	0.11	0.33	0.56	0.67
		6	a	0.91	0.76	0.61	0.91	0.76	0.91	0.91	0.91	0.76	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.56	0.22	0.11	0.33	0.45	0.56	0.45	0.67	0.89

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
11	6	0	a	0.15	0.46	0.46	0.15	0.15	0.46	0.15	0	0.46	0.30
			b	0	0	0	0	0	0	0	0	0.21	0
			c	0.22	0.33	0.11	0.22	0.33	0.11	0.22	0	0.45	0.78
		1	a	0.46	0	0.30	0.15	0.46	0.30	0.15	0	0.30	0.15
			b	0	0	0	0	0	0	0.19	0	0	0
			c	1.22	0.78	0.33	0.67	0.67	0.45	0.33	0.22	0.89	1.00
		2	a	0.46	0.61	0.61	0.46	0.76	0.15	0.46	0.46	0.30	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	1.33	1.22	0.78	0.67	1.00	0.89	0.78	0.89	1.45	1.67
		3	a	0.76	0.30	0.46	0.76	0.46	0.30	0.76	0.46	0.61	0.76
			b	0	0.14	0	0	0	0.17	0	0	0	0
			c	1.00	1.56	0.67	0.78	0.89	0.78	0.67	0.67	1.56	0.78
		4	a	0.61	0.76	0.76	0.46	0.15	0.76	0.91	0.30	0.61	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	1.00	0.56	0.67	1.00	0.56	0.56	0.56	1.00	0.78
		5	a	0.46	0.46	0.30	0.30	0.15	0.46	0.61	0.46	0.91	0.46
			b	0	0.21	0.19	0	0	0	0.17	0.33	0	0
			c	1.11	1.11	0.56	0.67	0.45	0.56	0.45	0.56	1.11	1.11
		6	a	0	0.15	0.46	0.15	0	0.30	0.30	0	0.15	0.15
			b	0	0	0	0	0	0	0.28	0	0	0
			c	1.22	0.89	0.67	0.56	0.56	0.67	0.45	0.56	1.00	1.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
12	6	0	a	0.15	0.15	0.15	0	0.30	0.30	0.15	0.46	0.30	0.15
			b	0	0	0	0	0	0	0	0	0.13	0
			c	0.56	0.56	0.22	0.11	0.56	0.56	0.33	0.22	0.89	0.45
		1	a	0.91	0.61	0.30	0.91	0.61	0.15	0.61	0.46	0.46	0.76
			b	0	0	0.24	0	0	0	0.19	0	0.37	0
			c	1.45	0.33	0.22	0.45	0.78	0.22	0.22	0.11	0.22	1.00
		2	a	0.91	0.61	0.46	0.61	0.76	1.06	0.46	0.61	0.76	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	1.33	0.56	0.89	1.22	1.00	0.78	0.45	1.11	0.89
		3	a	0.30	0.15	0.30	0.46	0.61	0.46	0.76	0.61	0.61	0.30
			b	0	0	0	0.19	0	0	0	0.21	0	0
			c	1.33	1.11	0.78	0.67	0.78	0.89	0.67	0.67	1.11	1.33
		4	a	0.91	1.06	0.91	0.76	0.61	1.06	0.46	0.61	0.91	0.61
			b	0	0.21	0	0	0	0	0	0	0	0
			c	0.78	0.67	0.56	0.56	0.56	0.45	0.67	0.56	0.67	0.89
		5	a	0.76	0.46	0.91	0.46	0.46	0.46	0.15	0.46	0.61	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	1.00	0.56	0.33	0.22	0.33	0.78	0.45	1.22	0.78
		6	a	0	0.15	0	0	0	0.15	0.30	0.15	0	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.45	0.45	0.22	0.67	0.45	0.45	0.22	0.33	0.56

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
13	7	0	a	0.46	0.61	0.76	0.30	0.61	0.61	0.46	0.56	0.46	0.46
			b	0.30	0.10	0	0	0	0.13	0	0	0	0.13
			c	0.33	0.56	0.67	0.45	0.22	0.56	0.67	0.56	0.56	0.33
		1	a	1.21	1.06	0.61	0.76	0.91	1.21	1.06	1.37	1.52	1.06
			b	0	0	0	0	0	0.13	0	0	0	0
			c	0.33	0.33	0.33	0.45	0.33	0.33	0.33	0.22	0.22	0.56
		2	a	0.61	1.06	0.91	0.91	1.37	1.06	1.21	0.91	0.76	0.76
			b	0	0	0	0.24	0	0	0	0	0	0
			c	0.22	0.56	0.56	0.45	0.56	0.33	0.33	0.56	0.11	1.56
		3	a	0.61	0.91	0.61	0.76	0.91	0.76	0.91	0.76	0.76	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0	0	0.11	0.22	0	0.11	0	0
		4	a	0.76	0.91	0.76	0.76	1.06	1.06	0.91	0.91	0.61	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0	0	0	0	0	0	0	0
		5	a	0.91	0.91	0.91	0.91	0.76	0.91	0.91	0.91	0.91	0.76
			b	0.09	0	0	0	0.07	0.09	0.21	0.17	0	0.13
			c	0	0	0	0	0	0.11	0.11	0.11	0	0.22
		6	a	1.06	0.76	1.06	1.06	0.91	0.91	1.06	0.91	0.91	0.91
			b	0.38	0.20	0.24	0	0.29	0.23	0	0	0.13	0.54
			c	0	0	0	0	0.11	0	0	0	0.22	0

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
14	7	0	a	0.91	0.76	0.30	0.46	0.91	0.76	0.91	1.06	0.61	0.91
			b	0.14	0	0	0.39	0	0	0	0	0	0
			c	0.11	0.33	0.33	0.67	0.33	0.33	0.33	0.33	0.33	0.33
		1	a	1.06	0.67	0.91	0.91	0.91	1.06	1.21	0.91	0.91	1.21
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.33	0.22	0.22	0.22	0.33	0.11	0	0.11	0
		2	a	1.06	1.06	0.91	0.76	0.76	1.21	1.06	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0.17	0
			c	0	0.45	0.45	0.11	0.33	0.11	0.45	0.22	0.22	0.11
		3	a	0.91	0.91	0.76	0.91	0.61	0.91	0.76	0.76	0.91	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0	0	0	0	0	0	0	0
		4	a	0.61	0.46	0.30	0.15	0.46	0.30	0.46	0.15	0.30	0.46
			b	0	0	0	0	0.19	0.37	0	0	0.22	0.18
			c	0.56	0.67	0.56	0.56	0.56	0.56	0.45	0.56	0.33	0.56
		5	a	0.91	0.91	0.91	0.91	0.91	1.06	1.06	1.06	0.91	0.91
			b	0.45	0.27	0	0	0.49	0.26	0.17	0	0.41	0.40
			c	0	0.11	0	0	0	0	0	0.11	0	0
		6	a	0.76	0.76	0.76	0.91	0.91	0.91	0.91	0.91	0.91	1.06
			b	0.13	0.32	0.27	0	0.33	0.33	0	0	0.43	0.70
			c	0.22	0	0	0.22	0.45	0.22	0.22	0.22	0.22	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
15	8	0	a	0.30	0.15	0.30	0.46	0.46	0.61	0.30	0	0.15	0.30
			b	0.13	0	0	0	0	0	0.28	0	0	0.14
			c	0.11	0	0.11	0	0.11	0	0.11	0	0.11	0
		1	a	0.15	0	0.30	0	0	0	0	0.46	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.45	0.22	0	0.11	0.11	0.11	0.11	0.33	0
		2	a	0.61	0.61	0.91	1.06	0.76	0.76	0.91	0.91	0.91	0.91
			b	0	0	0	0	0	0.14	0.28	0	0	0.19
			c	0.11	0.22	0	0	0	0.22	0.22	0.22	0	0.22
		3	a	0.46	0.61	0.46	0.30	0.76	0.91	0.61	0.46	0.61	0.61
			b	0.21	0	0.11	0.19	0	0.33	0	0	0	0
			c	0.22	0	0.22	0.11	0.11	0.45	0	0	0.11	0
		4	a	0.30	0.61	0.61	0.61	0.76	0.46	0.61	0.76	0.46	0.91
			b	0.18	0	0.11	0	0	0.17	0.19	0	0	0.1o
			c	0.22	0.22	0.45	0.22	0.22	0.22	0.22	0.33	0.22	0.45
		5	a	0.30	0	0.15	0.15	0.61	0.15	0.15	0	0.30	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.45	0.11	0.22	0.22	0.67	0.22	0.22	0.33	0.22
		6	a	0	0	0.15	0.15	0	0.15	0	0.15	0	0
			b	0	0	0	0	0	0	0	0	0.08	0.18
			c	0.45	0.45	0.33	0.33	0.67	0.33	0.45	0	0.11	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
16	9	0	a	0.15	0	0	0	0	0	0	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0.11	0.22	0.11	0	0.11	0.22	0.22	0
		1	a	0	0	0	0.15	0	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.67	0.78	0.56	0.78	0.89	0.67	0.45	0.45	0.67
		2	a	0	0.15	0	0	0.15	0	0	0	0.15	0.15
			b	0	0.14	0	0	0	0	0	0	0	0
			c	0.56	0.78	0.56	0.67	0.67	0.56	0.56	0.33	0.67	0.67
		3	a	0.30	0.30	0	0	0	0	0	0	0	0
			b	0	0	0	0	0.19	0	0	0	0	0
			c	0.45	0.67	0.56	0.33	0.45	0.56	0.33	0.22	0.22	0.56
		4	a	0	0	0	0	0	0.15	0	0.15	0.15	0
			b	0	0	0	0	0	0.19	0	0	0	0
			c	0.67	0.56	0.56	0.56	0.89	0.56	0.45	0.67	0.67	0.67
		5	a	0	0	0	0	0	0.30	0	0.15	0	0
			b	0	0	0	0	0	0	0	0	0.08	0.07
			c	0.67	0.56	0.56	0.67	0.78	0.67	0.56	0.56	0.45	0.67
		6	a	0.15	0.30	0	0	0	0.30	0	0	0	0
			b	0	0.08	0	0	0	0	0	0	0	0
			c	0.33	0.56	0.56	0.45	0.78	0.56	0.33	0.56	0.67	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
17	9	0	a	0	0	0.15	0.15	0.15	0	0.15	0	0	0
			b	0	0	0.21	0.14	0	0	0	0	0	0
			c	0.78	0.33	0.22	0.33	0.11	0.33	0.33	0.11	0	0.45
		1	a	0.15	0	0.15	0.15	0	0	0.15	0	0	0.15
			b	0	0	0.28	0	0	0	0	0	0	0
			c	0.56	0.67	0.78	0.45	0.67	0.56	0.67	0.67	0.56	0.67
		2	a	0.15	0.15	0	0	0	0	0.15	0.15	0	0.15
			b	0	0	0	0	0	0	0	0	0	0.24
			c	0.67	0.45	0.56	0.67	0.67	0.78	0.67	0.56	0.78	0.45
		3	a	0	0	0.30	0.30	0.30	0.15	0.15	0	0	0.15
			b	0	0	0	0	0	0	0.17	0	0	0
			c	0.45	0.56	0.56	0.56	0.56	0.67	0.56	0.45	0.56	0.45
		4	a	0	0.15	0.15	0	0.15	0	0.30	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.56	0.45	0.22	0.45	0.33	0.33	0.45	0.33	0.56
		5	a	0.15	0.15	0.15	0	0.15	0.15	0.15	0.15	0.15	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.33	0.78	0.33	0.45	0.67	0.45	0.45	0.22	0.78
		6	a	0.15	0.15	0.15	0	0	0	0	0	0	0
			b	0	0	0.08	0	0	0.14	0	0	0	0.20
			c	0.45	0.22	0.45	0.56	0.67	0.56	0.45	0.45	0.67	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
18	10	0	a	0.15	0.30	0	0	0	0.30	0	0.15	0.15	0.15
			b	0.36	0	0	0	0	0	0	0	0.09	0
			c	0.67	1.22	0.78	0.56	1.11	0.78	0.56	0.56	0.78	1.00
		1	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		2	a	0.61	0.61	0.15	0.30	0.91	0.46	0.61	0.46	0.76	0.61
			b	0	0.12	0.11	0.14	0.09	0.24	0	0.15	0	0
			c	0.22	0.45	0.22	0.11	0.22	0.33	0.11	0.11	0.33	0.45
		3	a	0.30	0.30	0.30	0.15	0.30	0.30	0.15	0.15	0	0.46
			b	0	0	0.17	0	0	0	0	0.15	0.11	0.11
			c	0.33	0.22	0.33	0.11	0.33	0.33	0.11	0.22	0.22	0.11
		4	a	0.15	0	0.15	0	0	0.15	0	0	0.15	0.15
			b	0.12	0	0	0	0	0	0.14	0	0	0
			c	0.22	0.56	0	0.45	0.67	0.22	0.11	0.45	0.11	0.56
		5	a	0.15	0.30	0	0.30	0.30	0.30	0.30	0	0	0.30
			b	0	0.09	0.11	0.12	0.19	0.09	0	0	0.10	0
			c	0.67	0.78	0.33	0.45	0.45	0.78	0.67	0.56	0.56	0.67
		6	a	0.30	0.30	0.61	0.30	0.46	0.30	0.30	0.46	0.15	0.46
			b	0	0.12	0	0	0.11	0	0	0	0	0
			c	0.45	0.56	0.33	0.22	0.33	0.33	0.33	0.33	0.33	0.56

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
19	10	0	a	0.15	0.30	0.15	0	0	0.30	0.46	0.15	0.15	0
			b	0.11	0	0	0	0.07	0	0	0	0.18	0
			c	0.67	0.56	0.56	0.45	0.78	0.45	0.56	0.78	0.67	0.56
		1	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		2	a	0	0.15	0.15	0.30	0.30	0.15	0.30	0	0.15	0.15
			b	0	0	0.25	0	0	0	0	0	0	0.11
			c	0	0	0.22	0.22	0.33	0.22	0.11	0.11	0.11	0.11
		3	a	0.15	0	0.15	0	0.15	0.30	0.15	0.15	0.30	0
			b	0	0	0	0	0.21	0	0	0.15	0	0.08
			c	0.11	0.22	0	0.11	0	0.11	0.11	0.11	0	0.33
		4	a	0	0	0	0.46	0.15	0.46	0.46	0.61	0.46	0.15
			b	0	0	0	0	0	0	0.14	0	0	0
			c	0.11	0.11	0	0	0.11	0.11	0	0	0	0.11
		5	a	0.30	0.61	0.46	0.30	0.30	0.30	0.46	0	0.15	0.61
			b	0	0	0.18	0	0	0.11	0.17	0	0	0.29
			c	0	0	0.11	0.33	0.22	0.11	0.45	0.11	0.22	0.22
		6	a	0.46	0.15	0.30	0.46	0.15	0.30	0.15	0	0.30	0.15
			b	0.11	0	0.29	0.32	0.15	0	0.29	0.38	0.12	0.19
			c	0.11	0.45	0.33	0.45	0.33	0.33	0.45	0.22	0.22	0.11

Table 34 (Continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
20	11	0	a	0.30	0.15	0.15	0	0.30	0.15	0.15	0.30	0	0.61
			b	0	0.13	0	0	0	0	0	0	0	0
			c	0.11	0.11	0.22	0.11	0.30	0.22	0.11	0.22	0	0.11
		1	a	0.46	0.76	0.15	0	0.15	0.30	0.30	0.46	0.76	0.46
			b	0	0.12	0.12	0.19	0	0	0	0	0	0
			c	0.11	0	0.33	0	0.22	0.33	0	0.22	0.22	0.11
		2	a	0	0	0	0	0	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.22	0.45	0.33	0.33	0.33	0.22	0.56	0.56	0.45
		3	a	0.61	0.76	0.91	0.76	0.91	0.76	0.76	0.76	0.76	0.76
			b	0	0.11	0	0	0	0	0	0	0	0
			c	0	0	0	0	0.22	0.11	0	0	0	0
		4	a	0.46	0.46	0.46	0.46	0.30	0.15	0.15	0.61	0.30	0.30
			b	0	0	0	0	0	0.15	0	0	0	0
			c	0.11	0	0	0.11	0.11	0.22	0.22	0	0.11	0.22
		5	a	0	0.15	0	0.15	0	0.30	0.30	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.22	0.11	0	0.11	0	0	0	0	0.11
		6	a	0	0	0	0	0	0.15	0	0	0	0.15
			b	0.11	0	0	0	0.15	0	0	0	0	0
			c	0.11	0	0.11	0.11	0.22	0.33	0	0.11	0.22	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
21	11	0	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		1	a	0.46	0.61	0.61	0.76	0.46	0.76	0.61	0.30	0.91	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.33	0.11	0	0.11	0.22	0	0	0	0
		2	a	0.46	o.30	0.61	0.15	0.30	0.15	0.30	0.30	0.15	0.46
			b	0	0	0	0.17	0	0	0	0.21	0	0.12
			c	0.11	0.11	0.67	0.33	0.56	0.46	0	0.22	0.56	0.56
		3	a	0.15	0.46	0.30	0.15	0.30	0	0.15	0.45	0.46	0
			b	0	0.13	0	0	0	0	0.15	0	0	0.17
			c	0.11	0.11	0	0.33	0.22	0	0.11	0	0	0.11
		4	a	0.61	0.15	0	0.46	0.61	0.30	0.30	0.30	0	0.15
			b	0	0	0	0.15	0	0.19	0	0	0	0
			c	0.45	0.67	0.45	0.11	0.56	0.33	0.11	0.22	0.11	0.11
		5	a	0	0.15	0	0.30	0	0.15	0.15	0	0.15	0.15
			b	0	0	0	0	0	0	0	0	0	0.19
			c	0.11	0.11	0.11	0.11	0.11	0	0.11	0.11	0	0.22
		6	a	0.15	0.15	0.30	0.15	0.61	0.15	0.30	0	0	0.15
			b	0.11	0.17	0	0	0	0.15	0	0	0	0.09
			c	0.22	0	0	0	0.22	0.45	0.22	0	0.33	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
22	12	0	a	0.76	0.76	0.61	0.61	0.46	0.46	0.61	0.91	0.46	0.91
			b	0.26	0.24	0.49	0.21	0.21	0	0	0.17	0.11	0.21
			c	0	0	0	0	0.33	0.11	0.11	0	0.11	0.11
		1	a	0.30	0.30	0	0.30	0.15	0.15	0.15	0.30	0.30	0
			b	0	0.28	0.17	0	0	0.14	0	0	0.21	0
			c	0.33	0.45	0.67	0.22	0.33	0.22	0.33	0.45	0.45	0.11
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	1.67	1.37	0.91	1.21	0.46	1.21	1.37	1.06	1.21	1.52
			b	0	0	0	0.24	0	0.30	0	0	0.11	0
			c	0.56	0.67	0.56	0.89	0.78	0.78	0.78	0.89	0.45	0.67
		4	a	0.61	0.46	0.61	1.21	0.30	0.30	0.30	0.76	0.61	0.61
			b	0	0.15	0	0.15	0	0.10	0.19	0.45	0	0.09
			c	0.67	1.00	0.67	0.89	0.89	1.00	0.67	0.67	0.78	0.89
		5	a	0.61	0.76	1.06	0.91	0.76	0.91	0.76	0.61	0.91	0.46
			b	0.36	0.39	0.33	0	0.14	0	0.41	1.35	0.14	0.39
			c	0	0	0	0	0	0	0	0	0	0
		6	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
23	13	0	a	0.15	0	0	0.15	0.15	0.15	0	0	0.15	0
			b	0.11	0	0	0	0	0	0	0	0.08	0
			c	0.11	0.45	0.33	0.78	0.33	0.33	0.33	0.22	0.33	0.45
		1	a	0.30	0	0.61	0.46	0.30	0	0.30	0.30	0.15	0.30
			b	0	0	0	0	0	0	0	0.28	0	0
			c	0.11	0.11	0.22	0.56	0.56	0.33	0.33	0.22	0.22	0.11
		2	a	0	0	0	0	0	0	0	0	0.23	0
			b	0	0	0	0	0.23	0	0	0	0	0
			c	0.50	0.50	0.50	0.67	0.17	0.67	0.50	0.67	0.67	0.50
		3	a	0	0	0.30	0.30	0.15	0.46	0.30	0.46	0.15	0.15
			b	0	0.19	0	0	0	0	0	0	0	0
			c	0.11	0.11	0.45	0	0	0.11	0	0.11	0	0.11
		4	a	0.15	0.46	0	0	0	0.15	0.15	0.15	0	0
			b	0	0	0	0	0	0	0	0.17	0	0
			c	0.11	0.33	0.67	0.45	0.22	0.33	0.33	0.11	0.22	0.45
		5	a	0	0.30	0	0.15	0.30	0.15	0	0	0	0.15
			b	0	0.17	0	0	0	0	0	0	0	0
			c	0	0.22	0	0.11	0.33	0	0.22	0.22	0	0
		6	a	0.15	0	0	0	0	0.15	0	0	0.46	0
			b	0	0.34	0	0	0	0	0	0	0	0
			c	0	0.33	0.22	0.22	0.22	0.22	0.11	0.11	0.11	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
24	13	0	a	0.15	0.15	0	0	0	0	0.15	0.15	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.11	0.11	0.22	0	0	0.11	0.22	0.33	0.11
		1	a	0.15	0.61	0.30	0.15	0.15	0.15	0.30	0.30	0.15	0.15
			b	0	0.17	0	0	0	0	0	0	0	0
			c	0.33	0.33	0.45	0.61	0.33	0.33	0.45	0.56	0.22	0.45
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	0.30	0.30	0.15	0.30	0.30	0.15	0.15	0.15	0.15	0.15
			b	0.17	0.14	0	0	0	0	0	0	0.12	0
			c	0.33	0.11	0.33	0.11	0.11	0.45	0.11	0	0	0.11
		4	a	0.30	0.15	0.30	0.15	0	0.15	0.46	0.15	0.15	0
			b	0.11	0.11	0	0.28	0	0	0	0.19	0	0
			c	0.56	0.45	0.56	0.45	0.45	0.33	0.67	0.67	0.67	0.67
		5	a	0.30	0.15	0	0.30	0.30	0.46	0.15	0	0.30	0.46
			b	0	0	0	0	0	0	0	0	0	0.19
			c	0.11	0	0	0.11	0	0.22	0	0	0	0.11
		6	a	0.15	0	0	0.30	0	0	0	0	0	0
			b	0	0	0	0	0.12	0	0.17	0	0	0
			c	0.45	0.11	0.11	0.11	0.22	0.22	0.11	0	0.11	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
25	14	0	a	0	0	0.15	0.15	0	0.15	0	0	0.15	0.15
			b	0	0.15	0	0	0.15	0	0	0	0	0
			c	0.22	0.11	0.33	0.11	0.11	0.33	0.45	0.22	0.33	0.22
		1	a	0.30	0.61	0.30	0.30	0.15	0	0	0	0.30	0.46
			b	0	0	0	0	0.21	0	0	0	0	0
			c	0.56	0.22	0.22	0	0.45	0.45	0.22	0.11	0.22	0.33
		2	a	0.30	0.15	0.46	0.15	0	0	0.30	0.30	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.78	0.56	0.45	0.56	0.45	0.56	0.56	0.67	0.56
		3	a	0.46	0.30	0.30	0.30	0.30	0.15	0.30	0.61	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0.17
			c	0.67	0.78	0.33	0.89	0.67	0.78	0.78	0.67	0.78	0.78
		4	a	0.46	0.30	0.30	0.15	0	0.30	0.46	0.46	0.76	0.15
			b	0.15	0	0.29	0.19	0	0.19	0	0	0.13	0
			c	0.67	0.56	0.22	0.56	0.67	0.56	0.67	0.56	0.56	0.78
		5	a	0.30	0.30	0.15	0.15	0.30	0	0.30	0.30	0.30	0.30
			b	0.12	0.14	0	0.21	0.13	0.29	0.33	0	0	0.27
			c	1.22	1.00	0.56	0.33	0.89	0.67	0.67	0.56	0.56	0.56
		6	a	0.46	0.15	0.30	0.30	0.76	0.46	0.30	0.61	0.61	0.61
			b	0.26	0.24	0.29	0.19	0.11	0.24	0.21	0	0	0
			c	0.78	0.67	0.56	0.67	0.67	0.67	0.78	0.56	0.89	0.78

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
26	14	0	a	0.15	0	0.15	0	0.30	0.15	0	0.15	0.15	0
			b	0	0	0	0	0	0	0.45	0	0	0
			c	0.11	0.11	0.45	0	0.11	0.11	0.11	0.11	0	0
		1	a	0.46	0.15	0.30	0	0.15	0.15	0.30	0.46	0.30	0.30
			b	0	0.14	0	0.21	0	0	0	0	0	0
			c	0.56	0.67	0.45	0.11	0.56	0.33	0.22	0.45	0.78	0.56
		2	a	0.15	0.15	0.15	0.15	0.30	0.30	0.15	0.15	0.30	0.30
			b	0.60	0.35	0	0	0.40	0.13	0.50	0.42	0.14	0.43
			c	1.00	1.33	1.00	0.45	0.89	0.89	0.67	0.33	1.00	0.67
		3	a	0.61	0.30	0.76	0.30	0.76	0.46	0.46	0.30	0.91	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	0.78	0.45	0.33	1.00	0.78	0.45	0.33	1.00	1.56
		4	a	0.76	0.76	0	0.15	0.91	0.46	0.46	0.46	0.46	0.91
			b	0.19	0.15	0.36	0	0.35	0.11	0	0.21	0	0
			c	1.00	0.78	0.45	0.56	0.89	0.56	0.56	0.22	0.89	0.45
		5	a	0.30	0.46	0.30	0.15	0.46	0.30	0.30	0.46	0.30	0.46
			b	0	0	0.26	0	0.23	0	0.39	0.21	0	0.11
			c	0.78	0.78	0.56	0.78	1.11	0.78	0.56	0.45	1.00	0.11
		6	a	0.15	0.61	0.46	0.46	0.15	0.61	0.15	0.61	0.30	0.15
			b	0.11	0	0.13	0.15	0	0	0	0	0	0
			c	0.45	0.67	0.78	0.33	0.45	0.22	0.33	0.78	0.67	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
27	15	0	a	0.30	0.30	0	0.30	0.15	0.30	0.15	0.30	0	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.11	0	0	0.11	0.33	0	0.33	0.22	0.11
		1	a	0.61	0	0.46	0.46	0.30	0	0.61	0.30	0.30	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	1.00	0.45	0.22	0.56	0.45	0.45	0.22	1.00	1.00
		2	a	0.15	0.46	0.15	0.15	0.30	0.30	0.15	0.15	0.30	0.15
			b	0	0	0	0	0	0	0	0.21	0	0
			c	0.89	1.00	0.45	0.56	0.67	0.56	0.56	0.67	1.00	0.78
		3	a	0.30	0	0	0.15	0	0.15	0	0.15	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	1.00	1.00	1.00	0.89	0.78	0.56	0.45	1.22	1.33
		4	a	0.46	0	0	0.30	0	0.30	0	0	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	0.67	0.56	0.33	0.67	0.67	0.56	0.56	0.67	0.67
		5	a	0.46	0.46	0	0.46	0.15	0	0	0	0.15	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	1.00	0.67	0.33	0.33	0.33	0.45	0	0.22	0.22	0.33
		6	a	0	0.30	0.76	0	0.46	0.30	0.15	0.15	0	0.15
			b	0	0	0	0	0	0.11	0	0	0	0
			c	0.56	1.00	0.56	0.33	1.11	0.56	0.33	0.22	1.00	0.89

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
28	15	0	a	0	0.15	0	0.15	0	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.33	0.11	0.11	0	0.22	0.11	0.11	0.45	0.11
		1	a	0.30	0.30	0.30	0.30	0	0.61	0	0.61	0	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	1.00	0.56	0.11	0.67	0.45	0	0.67	0.89	1.33
		2	a	0.61	0.30	0.30	0.15	0.30	0.61	0.30	0.46	0.46	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	1.79	1.67	0.89	0.56	1.33	1.33	0.89	1.00	1.33	1.56
		3	a	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	1.00	0.78	0.45	1.00	0.78	0.78	0.33	1.22	1.00
		4	a	0.15	0	0.15	0.15	0	0.15	0.15	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.78	0.56	0.45	1.11	0.89	0.56	0.33	0.78	0.56
		5	a	0.15	0.30	0.30	0.15	0.30	0.15	0.46	0.46	0.91	0.15
			b	0	0	0.19	0.19	0	0.09	0	0	0	0
			c	1.00	1.00	0.45	0.45	0.78	0.78	0.33	0.67	0.89	1.22
		6	a	0.30	0.61	0.46	0.46	0.30	0.30	0.30	0.61	0.91	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	1.11	0.45	0.45	0.78	0.78	0.33	0.78	1.11	0.78

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
29	16	0	a	0	0	0.15	0	0.15	0.15	0	0.30	0	0
			b	0	0	0	0	0	0	0	0	0.08	0
			c	0.33	0.22	0.33	0.33	0.11	0.45	0.33	0.11	0.22	0.45
		1	a	0	0	0.15	0	0	0	0	0	0.15	0
			b	0	0.14	0	0	0	0	0	0	0	0
			c	0.56	0.56	0.22	0.33	0.78	0.22	0.33	0.22	0.22	0.22
		2	a	0	0	0.15	0	0	0	0	0	0.15	0.15
			b	0.19	0.24	0.10	0	0	0	0	0	0	0
			c	0.56	0.67	0.67	0.56	0.67	0.67	0.78	0.45	0.78	0.56
		3	a	0	0	0.15	0	0	0	0.15	0	0	0.15
			b	0	0.11	0	0	0.12	0	0	0	0	0
			c	0.56	0.45	0.67	0.56	0.67	0.56	0.45	0.22	0.56	0.45
		4	a	0.15	0	0.15	0	0	0	0.15	0.30	0.15	0.30
			b	0	0	0	0	0	0.09	0.21	0.28	0	0.21
			c	0.33	0.22	0.11	0.11	0.22	0.22	0.11	0.11	0.33	0.22
		5	a	0.15	0	0.46	0.30	0.46	0.30	0.30	0.61	0.46	0.15
			b	0.34	0.11	0	0.12	0	0.11	0	0	0	0.17
			c	0	0	0.11	0	0	0.11	0	0	0	0
		6	a	0.46	0.30	0.30	0.46	0.15	0.15	0.15	0.15	0.15	0
			b	0.08	0	0	0	0	0	0	0	0	0
			c	0.56	0.78	0.22	0	0.45	0.67	0.11	0.22	0.89	0.78

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
30	16	0	a	0.15	0	0.30	0	0	0	0.46	0.15	0.15	0.30
			b	0	0	0.24	0	0	0	0.24	0.24	0	0
			c	0	0	0.22	0	0	0	0	0	0	0
		1	a	0.15	0.15	0.15	0	0	0	0	0	0	0.15
			b	0	0	0	0	0	0	0.24	0	0.14	0
			c	0.67	0.45	0.56	0.78	0.56	0.45	0.56	0.56	0.56	0.33
		2	a	0	0.15	0	0	0	0	0	0.15	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0	0.11	0.11	0	0.11	0.11	0	0	0.11
		3	a	0.15	0	0	0.15	0.15	0	0	0	0	0
			b	0.13	0	0	0	0	0.20	0	0.19	0	0.14
			c	0.45	0.45	0.56	0.11	0.22	0.11	0.11	0	0.33	0.45
		4	a	0.46	0.15	0.15	0.15	0.15	0.46	0.15	0	0	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	1.00	0.45	0.78	0.78	0.89	0.56	0.45	0.56	0.56
		5	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		6	a	0.61	0.30	0.30	0.30	0.61	0.76	0.46	0.61	0.46	0.76
			b	0	0	0	0.32	0.08	0	0.19	0	0	0
			c	0.22	0.45	0.22	0	0.56	0.32	0.22	0.22	0.22	0

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
31	17	0	a	0.91	1.06	0.61	0.91	0.76	0.91	0.91	1.06	1.21	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	1.33	1.00	1.00	0.22	1.00	1.22	0.89	1.00	1.11	1.33
		1	a	1.06	1.06	0.91	1.21	1.21	1.21	1.21	1.06	1.06	1.21
			b	0	0	0	0.19	0	0	0	0	0	0
			c	0.45	0.45	0.33	0.89	1.00	0.56	0.78	0.45	0.78	0.11
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	0.76	0.91	0.91	0.61	0.76	0.91	0.91	0.61	0.76	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.45	0.45	0.67	0	0.11	0.22	0	0.11	0
		4	a	1.06	1.37	0.61	0.91	0.76	0.91	1.06	0.61	0.76	1.06
			b	0	0	0	0	0.15	0	0.24	0.42	0.13	0
			c	0.45	0	0.11	0.11	0.33	0.33	0.67	0.33	0.56	0.11
		5	a	0.61	0.46	0.76	0.76	0.76	0.15	0.76	0.46	0.46	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.22	0.11	0.11	0	0.22	0.11	0.11	0	0.11
		6	a	0.61	0.76	0.61	0.61	0.46	0.46	0.30	0.91	0.61	0.76
			b	0.26	0	0	0	0	0	0	0	0.11	0
			c	0.11	0	0.22	0.33	0	0.33	0.33	0.11	0.11	0

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
32	17	0	a	0.91	0.76	0.76	0.76	0.91	0.76	0.91	0.91	0.91	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	0.89	0.78	0.56	0.67	1.00	0.56	0.56	0.56	1.11	0.11
		1	a	1.06	1.06	0.91	1.37	0.91	0.91	0.91	0.91	0.91	0.91
			b	0	0	0	0	0	0	0	0	0	0
			C	0.33	0.45	0	0.11	0	0	0.11	0.22	0.22	0.22
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	0.91	1.06	1.06	0.76	0.91	0.91	1.06	0.91	0.91	0.76
			b	0.20	0.11	0	0.21	0.20	0.15	0	0	0.09	0.11
			c	0	0.11	0	0	0.11	0.11	0	0	0	0
		4	a	0.91	1.21	1.06	0.91	0.76	0.91	0.76	1.06	0.91	0.91
			b	0	0	0	0	0.14	0	0.19	0	0.17	0
			c	0.56	0.78	0.67	0.33	0.22	0.45	0.45	0.45	0.33	1.00
		5	a	0.61	0.91	0.76	0.76	0.91	0.76	0.76	0.91	0.76	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0	0	0.11	0.11	0	0	0	0	0
		6	a	0.61	0.76	0.61	0.30	0.30	0.30	0.61	0.61	0.76	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.56	0.22	0.11	0.33	0.33	0.22	0	0.33	0

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
33	18	0	a	0.91	0.91	0.68	0.23	0.68	0.46	0.23	0.46	0.68	0.68
			b	0	0	0	0	0	0.11	0	0	0	0
			c	0	0	0.33	0	0	0	0	0	0	0
		1	a	0	0	0.15	0.30	0.15	0.15	0.15	0	0	0.15
			b	0	0	0.19	0	0.13	0	0	0	0	0.11
			c	0.33	0.22	0.33	0.45	0.56	0.56	0.45	0.56	0.45	0.33
		2	a	0.15	0	0.15	0	0	0	0	0.15	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.45	0.67	0.45	0.67	0.11	0.45	0.45	0.33	0.45
		3	a	0.30	0.30	0.46	0.15	0.30	0.15	0	0.30	0.30	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.45	0.56	0.11	0.56	0.56	0.78	0.45	0.56	0.67
		4	a	0.46	0.76	0.91	0.61	0.61	0.76	0.15	0.76	0.76	0.61
			b	0	0	0	0.11	0	0	0	0	0	0
			c	0	0.33	0.11	0	0.56	0.11	0.11	0	0.11	0.11
		5	a	0.30	0.61	0.61	0.46	0.76	0.61	0.61	0.61	0.61	0.46
			b	0	0.11	0.12	0.25	0.11	0.10	0	0.24	0.11	0.09
			c	0.45	0.11	0.22	0.45	0.22	0.11	0.11	0.22	0.22	0.22
		6	a	0.91	0.91	1.06	0.91	1.06	1.06	0.91	0.91	1.06	0.61
			b	0.22	0.14	0.26	0.32	0.15	0	0	0	0.22	0.37
			c	0	0	0.11	0	0	0	0	0.11	0	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
34	18	0	a	0.30	0.30	0.15	0.46	0.46	0.30	0	0.30	0.30	0.15
			b	0	0	0.21	0	0	0	0	0	0	0.14
			c	0	0	0	0	0	0	0	0	0	0
		1	a	0.15	0.15	0.15	0.61	0.46	0.30	0.30	0.15	0	0.30
			b	0	0.10	0	0	0	0	0	0	0	0
			c	0.22	0.56	0.45	0.33	0.33	0.22	0.22	0.33	0.33	0.56
		2	a	0.30	0.15	0.15	0.15	0	0.46	0	0	0	0.15
			b	0.17	0	0	0	0.08	0	0	0.17	0	0.12
			c	0.67	0.67	0.67	0.45	0.67	0.33	0.56	0.56	0.33	0.56
		3	a	1.06	0.91	0.61	0.46	0.76	0.15	0.61	0.61	0.76	0.76
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.11	0.11	0	0.45	0.22	0.33	0.45	0	0.22
		4	a	0.76	0.76	0.61	0.76	0.46	0.91	1.06	0.46	0.46	0.76
			b	0.08	0	0.08	0	0.09	0	0	0	0	0.09
			c	0.11	0.33	0.45	0.45	0.45	0.11	0	0.33	0.33	0.11
		5	a	0.91	0.91	0.61	0.61	0.91	0.76	0.76	0.76	0.91	0.91
			b	0	0	0	0	0.09	0	0	0	0	0
			c	0.22	0.22	0.45	0.22	0.11	0.11	0.22	0.33	0.11	0.11
		6	a	0.46	0.91	0.61	0.91	1.06	0.61	0.76	0.46	0.91	0.61
			b	0	0.08	0	0.13	0	0	0	0.14	0	0.07
			c	0.33	0.33	0.22	0.22	0.56	0.11	0.33	0.22	0.67	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
35	19	0	a	0.15	0	0.46	0.15	0.30	0.61	0.15	0.30	0.61	0
			b	0.14	0	0.42	0	0	0	0	0	0.55	0
			c	0.33	0.33	0	0.33	0.11	0.22	0	0	0.11	0.33
		1	a	0.30	0.30	0	0.15	0.46	0.30	0	0.15	0.30	0.46
			b	0	0	0	0	0	0	0	0	0	0.19
			c	0.56	0.78	0.78	1.00	0.67	0.78	0.22	0.67	0.56	0.67
		2	a	0.15	0.15	0	0	0	0.30	0.30	0	0.15	0.15
			b	0	0	0	0.39	0.22	0	0	0.21	0.15	0
			c	0.56	0.56	0.22	0.22	0.56	0.67	0.56	0.22	0.67	0.67
		3	a	0.30	0	0.30	0.15	0.15	0.15	0	0	0	0
			b	0.47	0.15	0.44	0.24	0.31	0.32	0.42	0.95	0.29	0.11
			c	0.33	0.67	0.22	0.22	0.67	0.45	0.11	0.22	0.78	0.67
		4	a	0.46	0.15	0.15	0.46	0	0.30	0.30	0.61	0	0.15
			b	0.62	0.50	0.19	0	0.20	0.08	0	0.42	0.27	0.15
			c	0.22	0.78	0.22	0.22	0.56	0.33	0.33	0	0.11	0
		5	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		6	a	0.46	0.15	0.46	0.46	0.61	0.46	0.30	0.15	0	0.15
			b	0	0	0.12	0.10	0	0	0.17	0.75	0	0
			c	0.78	0.56	0.22	0	0.67	0.45	0.11	0	0.56	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
36	19	0	a	0.15	0.46	0.61	0.30	0.30	0.46	0.30	0.61	0.30	0.46
			b	0	0	0	0.24	0	0.21	0	0	0.14	0
			c	0.22	0.45	0.45	0.33	0.33	0.22	0.33	0.22	0.45	0.22
		1	a	0	0	0.30	0	0	0.15	0	0.30	0	0.30
			b	0	0	0	0.48	0	0	0	0	0	0.13
			c	0.67	0.67	0.33	0.33	0.67	0.67	0.33	0.45	0.45	0.45
		2	a	0.15	0.15	0.30	0.61	0.61	0.30	0.76	0	0.30	0.15
			b	0.39	0.13	0.17	0.37	0.46	0	0.49	0.48	0.32	0.36
			c	0.45	0.56	0.11	0.45	0.56	0.56	0.11	0.33	0.22	0.33
		3	a	0.15	0.15	0	0	0.15	0	0.30	0	0	0
			b	0.28	0	0.34	0.21	0.34	0.14	0.17	0.39	0.15	0
			c	0.22	0.33	0.11	0.22	0.45	0.56	0.22	0.22	0.22	0.22
		4	a	0.91	0.91	0	0.46	0.46	0.46	0.46	0	0.46	0.91
			b	0	0	0	0	0.36	0	0	0.50	0.39	0
			c	1.00	0.34	0	0	0.34	1.00	0.34	0	0.34	0
		5	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		6	a	0.30	0.15	0.15	0	0	0.15	0	0	0	0.15
			b	0	0	0	0.12	0	0	0.17	0.19	0	0
			c	0.11	0.45	0.22	0.33	0.45	0.67	0.33	0.11	0.56	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
37	20	0	a	0	0.46	0	0.46	0	0	0	0.46	0.46	0
			b	0	0	0	0	0	0.36	0	0	0	0
			c	0.34	0.34	0.67	0.34	0.67	0.34	0.34	0	0.67	0.67
		1	a	0.30	0	0	0	0.15	0	0	0.30	0	0.15
			b	0	0.14	0	0	0.17	0	0	0	0	0.17
			c	0.56	0.45	0	0	0.22	0	0	0	0	0.22
		2	a	0.46	0.15	0.76	0.76	0.46	0.61	0.76	0.46	0.15	0.15
			b	0.45	0	0.77	0	0.17	0.21	0.24	0	0	0.19
			c	0.78	0.78	1.00	0.56	0.67	0.56	0.67	0.56	0.45	0.56
		3	a	0.46	0.76	0.15	0.15	0.46	0.76	0.61	0.46	0.46	0.46
			b	0	0	0.25	0	0.17	0.17	0.17	0	0.19	0.12
			c	0.89	0.11	0.67	0.45	0.56	0.89	0.78	0.33	0.67	0.78
		4	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		5	a	0.46	0.30	0.46	0.30	0.61	0.61	0.45	0.61	0.15	0.46
			b	0	0	0.14	0	0	0.11	0	0	0	0
			c	0.45	0.11	0.22	0	0.22	0.11	0	0.45	0.33	0.56
		6	a	0.76	0.91	0.61	0.76	0.91	0.91	0.91	0.76	0.76	0.61
			b	0	0	0	0.14	0.25	0	0	0	0	0
			c	0.78	1.22	0.33	0.22	0.67	0.45	0.33	0	0.78	1.00

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
38	20	0	a	0.30	0.30	0.15	0	0.30	0.30	0.46	0.15	0.46	0.15
			b	0	0	0	0	0.17	0	0	0	0	0
			c	0	0	0.11	0	0.33	0.11	0.22	0.11	0.22	0
		1	a	0.76	0.30	0.30	0.46	0	0.15	0	0.15	0.30	0.30
			b	0	0.22	0.45	0.19	0.12	0.12	0.24	0.24	0	0
			c	0.45	0.56	0.33	0.45	0.22	0.33	0.45	0.11	0.78	0.56
		2	a	0.46	0.30	0.46	1.06	0.30	0.30	0.46	0.30	0.30	0.15
			b	0.30	0	0	0	0.15	0	0	0	0	0.31
			c	0.45	1.00	0.56	0.56	0.78	0.45	0.45	0.56	1.00	0.67
		3	a	0	0.61	0.76	0.61	0.61	0.15	0.76	0.46	0.30	0.61
			b	0.17	0	0.15	0.38	0	0	0	0	0.49	0.14
			c	0.56	0.89	0.67	0.33	0.89	0.78	0.45	0.45	0.67	0.56
		4	a b c	-	-	-	-	-	-	-	-	-	-
		5	a	1.21	0.91	0.76	1.06	0.61	0.91	0.91	0.61	0.61	0.61
			b	0	0	0	0	0	0	0.24	0	0	0.13
			c	0.11	0	0	0	0.22	0.33	0	0	0	0.22
		6	a	1.06	0.76	0.91	0.76	0.91	1.21	0.91	0.76	0.76	0.91
			b	0	0	0	0	0.14	0	0.17	0	0	0
			c	0.11	0.56	0	0	0.33	0	0.11	0.11	0.45	0.22

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
39	21	0	a	0.15	0.46	0	0.30	0.30	0.15	0.30	0.15	0.30	0.15
			b	0	0	0	0.34	0.26	0.33	0.30	0	0	0.28
			c	0.78	0.78	0.78	0.78	0.78	0.67	0.67	0.67	0.67	0.67
		1	a	0	0.30	0.46	0.30	0.15	0.15	0.46	0	0.15	0.30
			b	0.11	0	0	0	0	0	0	0	0	0
			c	1.45	0.56	0.67	0.45	0.45	0.22	0.45	0.45	0.67	0.67
		2	a	0.30	0.46	0.15	0.30	0.15	0.30	0.15	0.15	0.15	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.78	0.56	0.67	0.67	0.33	0.33	0.22	1.22	0.89
		3	a	0.15	0	0	0.30	0.30	0.15	0.15	0.61	0.15	0.15
			b	0	0	0.09	0	0.08	0	0.15	0	0	0
			c	1.22	0.89	0.67	0.45	0.45	0.45	0.45	0.56	1.00	1.00
		4	a	0.15	0	0.15	0.15	0.30	0	0.30	0.15	0.30	0.15
			b	0	0.14	0	0	0	0.08	0.19	0	0	0
			c	0.67	0.89	0.45	0.56	0.89	0.56	0.67	0.56	0.78	0.78
		5	a	0.61	0.15	0.15	0.15	0.30	0.61	0.61	0.61	0.30	0.76
			b	0	0	0	0	0	0.14	0	0	0	0
			c	1.00	1.11	0.67	0.78	0.67	1.00	1.11	0.78	1.22	0.89
		6	a	0.15	0	0	0	0.15	0	0	0.15	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.78	0.67	0.33	0.67	0.33	0.45	0.67	0.33	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
40	21	0	a	0.15	0.46	0	0.46	0	0.15	0.15	0.15	0.15	0.30
			b	0	0	0	0	0	0	0.17	0	0	0
			c	0.33	0.67	0.11	0	0.11	0	0.11	0.11	0	0.22
		1	a	0.30	0.30	0.15	0.15	0.46	0.30	0.61	0.15	0.30	0.30
			b	0	0	0	0.17	0	0	0	0	0	0
			c	0.11	0.78	0.22	0.33	0.11	0.22	0.33	0.33	0.56	0.56
		2	a	0.46	0.30	0.61	0.30	0.46	0.61	0.61	0.61	0.15	0.46
			b	0	0	0	0	0.14	0.14	0	0	0	0
			c	0.67	0.56	0.67	0.56	0.89	0.67	0	0.67	1.45	0.56
		3	a	0.46	0.30	0.30	0.76	0.30	0.30	0.15	0.76	0.46	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	0.89	0.45	0.67	0.89	0.56	0.56	0.78	1.45	0.78
		4	a	0.46	0.46	0.30	0.76	0.61	0.76	0.46	0.46	0.76	0.30
			b	0	0.13	0	0	0	0	0	0	0	0
			c	1.56	1.11	0.78	0.56	0.45	0.78	0.56	0.45	0.78	0.56
		5	a	0.15	0.46	0.15	0.30	0	0.30	0.30	0.46	0.30	0.30
			b	0	0	0.14	0	0.09	0.08	0.17	0	0	0
			c	1.00	1.11	0.67	1.00	1.00	0.33	0.67	0.56	0.78	0.89
		6	a	0.30	0	0.15	0	0.30	0	0	0.15	0	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	1.00	0.45	0.11	0.67	0.33	0.45	0.45	0.89	0.89

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
41	22	0	a	0.30	0	0	0.15	0.15	0	0	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0	0.56	0.33	0.45	0.22	0.33	0.11	0.22	0.11
		1	a	0.15	0.15	0.46	0.61	0.15	0	0.30	0	0.15	0
			b	0	0	0.24	0.08	0	0.29	0	0	0	0.19
			c	0.33	0.89	0.56	0.45	0.45	0.89	0.56	0.45	0.56	0.67
		2	a	0.46	0.15	0.15	0.15	0.15	0.15	0.46	0.30	0	0.30
			b	0.20	0.13	0.24	0.19	0.11	0.11	0	0	0	0.24
			c	0.45	1.22	0.67	0.89	0.67	0.67	0.56	0.67	0.67	0.89
		3	a	0.61	0.46	0.46	0.15	0.30	0.61	0.30	0.30	0.61	0.30
			b	0	0	0	0	0.11	0	0	0	0	0
			c	0.33	0.33	0.33	0	0.67	0.33	0.33	0.11	0.67	0.33
		4	a	0.30	0.61	0.61	0.61	0.46	0.46	0.61	0	0.15	1.21
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.78	0.45	0.22	0.33	0.22	0.33	0.11	0	0.45
		5	a	0.61	0.76	0.46	0.46	0.61	1.06	0.76	0.61	0.46	0.91
			b	0	0	0	0.19	0	0.09	0	0	0	0
			c	0.33	0.33	0	0.45	0.56	0.22	0.22	0	0.33	0.22
		6	a	0.76	0.76	0.46	0.91	0.61	0.46	0.61	0.91	0.76	0.76
			b	0	0	0	0	0.11	0	0	0	0	0
			c	0.33	0.33	0.22	0.11	0.33	0.22	0.22	0.11	0.78	0.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
42	23	0	a	0.46	0.46	0.46	0.15	0.30	0.46	0.61	0.61	0	0.46
			b	0	0	0	0.19	0	0	0	0	0	0
			c	0.22	0.11	0	0.11	0.33	0.33	0	0	0.45	0
		1	a	0.91	0.91	0.23	0.91	0.91	0.68	0.46	0.23	0.46	0.46
			b	0	0	0	0	0.21	0	0	0	0	0
			c	0.50	0	0.17	0.17	0	0.33	0.50	0.17	0.67	0.83
		2	a	0.46	0.15	0.15	0.46	0.15	0.15	0.30	0.15	0	0.30
			b	0	0.21	0	0	0	0	0	0	0	0
			c	0.56	0.56	0.56	0.22	0.45	0.67	0.45	0.11	0.78	0.67
		3	a	0.30	0.30	0.15	0.15	0.46	0.46	0.30	0.30	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0	0.11	0.22	0.22	0.11	0.11	0.22	0.45	0.22
		4	a	0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.30	0.46
			b	0.28	0	0.17	0	0	0	0	0	0	0
			c	0.22	0.22	0.33	0.22	0.33	0.33	0.33	0.33	0.11	0.33
		5	a	0.76	0.46	0.30	0.30	0.61	0.61	0.46	0.61	0.61	0.30
			b	0	0	0	0	0	0	0	0	0	0.21
			c	0.33	0.78	0.22	0	0.56	0.22	0.11	0.11	0.89	0.89
		6	a	0.23	0.46	0	0	0.23	0.23	0	0.23	0.46	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.67	0.50	0.67	0.67	0.67	0.67	0.50	0.67	0.83

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
43	23	0	a	0.30	0.46	0.30	0.46	0.30	0.46	0.46	0.30	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.11	0.11	0.11	0.11	0.11	0	0	0	0.22
		1	a	0.46	0	0.46	0.23	0.46	0.46	0.68	0.46	0.23	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	1.00	0.17	0.67	0.67	0.83	0.67	0.50	0.67	1.33	0.67
		2	a	0.61	0.76	0.30	0.76	0.30	0.46	0.61	0.46	0.46	0.61
			b	0	0	0.19	0.14	0	0	0.24	0	0	0
			c	0.78	0.45	0.45	0.22	0.45	0.45	0.33	0.56	0.89	0.56
		3	a	0.15	0	0	0.15	0.15	0.15	0.15	0.15	0	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.11	0.33	0.33	0	0.33	0	0.33	0.11	0
		4	a	0.15	0.30	0.15	0.30	0.15	0	0.30	0.15	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.33	0	0.11	0	0.11	0	0.11	0.11	0.33
		5	a	0.76	0.76	0.61	0.46	0.61	0.91	0.76	0.30	0.91	0.61
			b	0	0	0	0	0	0	0	0	0	0
			C	0.89	0.89	0.78	0.45	0.78	0.56	0.56	0.45	1.22	1.00
		6	a	0.15	0.46	0.15	0.61	0.15	0.30	0.46	0.76	0.61	0.61
			b	0	0	0	0	0	0.15	0	0	0	0
			c	1.33	1.22	0.45	0.33	0.56	0.45	0.22	0.45	0.78	1.11

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
44	24	0	a	0.30	0.30	0.46	0.46	0.15	0.30	0.46	0.15	0	0.30
			b	0	0	0.15	0	0.11	0	0	0	0	0
			c	0.45	0.33	0.78	0.33	0.67	0.67	0.11	0.45	0.56	0.33
		1	a	0.15	0.15	0.15	0.30	0.30	0.15	0.30	0.15	0.46	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.56	0.22	0.45	0.67	0.56	0.45	0.11	0.45	0.45
		2	a	0.15	0	0.15	0.30	0	0.15	0.15	0.46	0	0.15
			b	0.29	0	0.15	0	0.29	0.12	0	0	0.10	0.11
			c	0.67	0.67	0.45	0.45	0.67	0.45	0.11	0.33	0.67	0.56
		3	a	0.15	0.15	0.15	0.15	0	0.15	0	0.30	0.15	0
			b	0	0.30	0.14	0	0	0.15	0	0	0	0
			c	0.33	0.11	0.11	0.33	0.22	0.45	0.11	0.45	0.45	0.56
		4	a	0.15	0	0.15	0.15	0	0	0	0.15	0	0
			b	0	0.15	0	0	0.14	0.31	0	0	0	0
			c	0.22	0.45	0.45	0.45	0.45	0.45	0.56	0.45	0.33	0.22
		5	a	0.30	0.15	0.15	0	0	0.15	0.30	0	0.30	0.15
			b	0	0	0.17	0	0	0	0	0	0	0
			c	0.78	0.45	0.56	0.33	0.78	0.22	0.33	0.33	0.56	0.78
		6	a	0.30	0.15	0	0	0	0.46	0	0.30	0	0
			b	0	0	0	0	0.14	0	0	0	0	0
			c	0.45	0.45	0.11	0.33	0.33	0.33	0.33	0.11	0.33	0.56

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
45	25	0	a	0.15	0	0	0	0	0	0	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.11	0	0	0	0	0.11	0	0.11	0.11
		1	a	0.30	0.30	0.76	0.61	0.46	0	0.46	0.61	0.30	0.30
			b	0	0	0	0	0	0	0.14	0	0	0
			c	0.56	0.89	0.33	0.33	0.67	0.45	0.33	0.56	0.33	0.67
		2	a	0.46	0.15	0	0.30	0.61	0.15	0.15	0.30	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.11	0.11	0.22	0.45	0.11	0	0.11	0	0.33
		3	a	0.15	0.61	0.46	0.30	0.61	0.30	0.46	0.46	0.15	0.46
			b	0.12	0	0	0	0	0	0	0	0	0
			c	0.22	0.11	0.11	0	0	0	0	0	0.22	0.11
		4	a	0.30	0.30	0.30	0.30	0.15	0.15	0	0.30	0	0
			b	0	0	0	0	0	0	0	0	0	0.23
			c	0.11	0.11	0.11	0	0.22	0.11	0	0.22	0	0.11
		5	a	0	0.15	0	0	0	0	0.15	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.11	0	0.11	0.11	0	0	0	0.11	0
		6	a	0.15	0	0.15	0	0.30	0.30	0.15	0.15	0.46	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.67	0.33	0.11	0.45	0.11	0	0.22	0.78	0.78

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
46	25	0	a	0	0	0	0	0	0.15	0.30	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.22	0	0	0.11	0	0.11	0	0	0
		1	a	0.30	0.61	0.61	0.46	0	0.30	0.76	0.61	0.46	0.46
			b	0	0	0	0	0	0	0.14	0	0	0.14
			c	0.89	0.67	0.67	0.78	0.67	0.45	0.33	0.45	0.56	0.45
		2	a	0.61	0	0.30	0.46	0.15	0.15	0.30	0.30	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0	0.22	0.11	0.45	0.45	0	0	0.11	0
		3	a	0.30	0.46	0.46	0.30	0.30	0.61	0.46	0	0.30	0.46
			b	0	0.50	0.32	0	0	0	0	0	0.17	0.14
			c	0.22	0.45	0.22	0.11	0.33	0.11	0	0	0.33	0
		4	a	0.46	0.30	0.30	0.30	0.46	0.46	0.30	0	0.15	0.30
			b	0	0	0	0	0	0	0	0	0	0.12
			c	0	0.33	0.22	0	0.67	0.45	0.22	0	0.45	0.67
		5	a	0.30	0.15	0.15	0.15	0.15	0.15	0.61	0	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.11	0	0.33	0.33	0	0	0.11	0.33	0.11
		6	a	0.76	1.21	0.61	0.91	1.06	1.06	0.76	0.91	0.76	0.91
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.45	0.22	0.78	0.78	0.67	0.67	0.45	0.67	0.56

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
47	26	0	a	0.46	0.46	0.15	0	0	0	0.15	0	0.15	0.15
			b	0.10	0	0	0	0	0	0.17	0	0.11	0
			c	0.22	0.33	0.22	0.11	0.33	0.11	0.33	0.56	0.33	0.22
		1	a	0.15	0.30	0	0.46	0.30	0.30	0	0.46	0.15	0.15
			b	0	0	0	0	0	0	0	0	0.13	0
			c	0.56	0.67	0.45	0.67	0.56	0.89	0.67	0.56	0.45	0.56
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	0	0	0	0	0	0.15	0.30	0	0	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.67	0.11	0.22	0.11	0.33	0.45	0.45	0.33	0.33
		4	a	0	0.46	0.46	0.15	0.30	0.15	0.46	0.15	0.30	0.30
			b	0.21	0	0.12	0.20	0.12	0.62	0	0	0.11	0
			c	0.56	0.33	0.45	0.33	0.67	0.45	0.67	0.33	0.22	0.67
		5	a	0.15	0.30	0	0.46	0	0.15	0	0	0	0.15
			b	0	0	0	0	0.13	0	0	0	0	0
			c	0.33	0.56	0.33	0.45	0.67	0.45	0.33	0.11	0.11	0.45
		6	a	0	0	0.30	0.15	0.15	0.30	0.15	0	0.15	0.30
			b	0.10	0	0	0	0	0	0	0	0.09	0
			c	0.22	0.67	0.22	0.22	0.33	0.33	0	0.11	0.22	0.45

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
48	26	0	a	0.46	0.46	0.46	0.30	0.15	0.15	0.15	0.30	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.67	0.67	0.45	0.67	0.56	0.45	0.33	0.56	0.56	0.67
		1	a	0.30	0.30	0	0.46	0	0.15	0	0	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.56	0.56	0.22	0.67	0.67	0.22	0.56	0.22	0.56
		2	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										
		3	a	0	0	0	0	0.15	0	0	0	0.15	0
			b	0	0.08	0	0	0	0	0	0	0	0
			c	0.67	0.67	0.67	0.67	0.67	0.78	0.56	0.56	0.67	0.67
		4	a	0.15	0.15	0.15	0.61	0.30	0.30	0.15	0.15	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.67	0.67	0.67	0.67	0.67	0.78	0.67	0.78	0.56
		5	a	0.30	0.46	0	0	0.30	0	0	0	0.46	0.30
			b	0	0	0	0	0	0	0	0.21	0	0.08
			c	0.33	0.22	o.33	0.11	0.45	0	0.22	0.22	0.22	0.45
		6	a	0	0.46	0	0.46	0	0	0.61	0.15	0.30	0
			b	0.08	0.08	0	0.17	0	0	0	0	0	0
			c	0.33	0.78	0.22	0.45	0.11	0.45	0.22	0.11	0.56	0.33

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
49	27	0	a	0	0	0	0.15	0.15	0.15	0.46	0	0	0.15
			b	0	0	0	0	0	0	0	0	0	0
			c	0.22	0.33	0.22	0.33	0.11	0.22	0.33	0.11	0.11	0.22
		1	a	0.15	0.15	0.30	0.30	0.61	0	0.30	0	0.15	0.46
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	0.45	0.11	0.22	0.22	0.33	0.33	0.45	0.22	0.67
		2	a	0.30	0.15	0.15	0.61	0.30	0.15	0.15	0	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.11	0.33	0	0.33	0.56	0.45	0.11	0.33	0.67	0.56
		3	a	0	0	0.15	0.15	0	0.46	0	0.15	0	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.33	0.67	0.22	0.11	0.22	0.56	0	0	0.22	0.33
		4	a	0.15	0.30	0.30	0.30	0.30	0.76	0.61	0.30	0.30	0.15
			b	0	0	0	0	0	0.14	0	0	0	0
			c	0.33	0.56	0.45	0.33	0.78	0.45	0.33	0.11	0.67	0.67
		5	a	0.76	0.61	0.76	0.76	0.91	0.61	0.76	0.61	0.46	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	1.22	0.22	0.11	0.22	1.00	0.89	0.22	0	0.22	0.56
		6	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										

Table 34 (continued)

Eye No.	Subject No.	Visit No.		STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
50	27	0	a	0.30	0	0.30	0	0.15	0.15	0.30	0.15	0.15	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0	0.22	0.33	0.45	0.22	0.22	0.33	0.33	0.11	0.45
		1	a	0.46	0.46	0.46	0.30	0.30	0.61	0.15	0.15	0.30	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.22	0.33	0.33	0.11	0.11	0.22	0.11	0.33	0.56
		2	a	0	0.15	0.30	0.46	0	0	0	0.15	0.15	0
			b	0	0	0	0	0	0	0	0	0	0
			c	0.45	0.33	0	0.22	0.22	0.11	0.22	0.22	1.00	0.45
		3	a	0.30	0.46	0.76	0.46	0.61	0.76	0.46	0.61	0.15	0.61
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	1.33	0.22	0.78	0.67	0.45	0.56	0.22	1.33	0.45
		4	a	0.15	0.30	0.30	0.46	0.15	0	0.30	0.46	0.30	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.56	1.33	0.33	0.33	0.67	0.56	0.56	0.33	1.00	0.89
		5	a	0.30	0.15	0.46	0.46	0.15	0.30	0.15	0	0.15	0.30
			b	0	0	0	0	0	0	0	0	0	0
			c	0.78	0.89	0.67	0.11	0.56	0.67	0.45	0.33	0.67	0.45
		6	a										
			b	-	-	-	-	-	-	-	-	-	-
			c										

Table 35 : STUDY No. 4 - Summary table of certain of the results of the sum correlation analyses[+] undertaken upon the ten possible pairings of factor combinations.

(Refer to TABLES 17 and 18: pages 235 and 238, respectively, TABLES 32 - 34: pages 315 - 389, and APPENDIX VIC: pages 439 - 451).

Table 35A: Whole group of eyes (N = 50).

Table 35B: Division of eyes on the basis of sex : male (N = 34), female (N = 16).

Table 35C: Division of eyes on the basis of monocular Landolt visual acuity attainable with optimum soft contact lens : 6/4 constant (N = 38), 6/4 variable (N = 12).

Table 35D: Division of eyes on the basis of their ocular refraction : total spherical errors (N = 24), total sphero-cylindrical errors (N = 26).

For each pair of factor combinations in TABLES 35A - 35D, the data are listed in a uniform sequence: the Pearson product-moment correlation coefficient (r) and an indication of the relevant statistical significance level, and the two constants (a, b) in the general equation of the best-fit linear regression line, viz, $Y = a + b X$.

[+] Restrictions upon space preclude the tabulation here of all the results of the several sum correlation analyses undertaken (refer to Table 18: page 238) on the data produced in STUDY NO. 4. These further results are on file in the Soft Contact Lens Research Unit, Department of Ophthalmic Optics, The University of Aston in Birmingham.

Table 35A : Correlation analysis results - Whole group of eyes (N = 50)

FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
1 TV Score	r	-0.733	-0.953	-0.908	-0.872	-0.800	-0.942	-0.911
vs	(p)	<0.02	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
Blink Rate	a	16.199	27.035	32.867	24.648	26.044	24.667	27.192
@ Off	b	-0.005	-0.014	-0.018	-0.015	-0.013	-0.018	-0.021
2 Response	r	0.823	0.883	0.888	0.952	0.835	0.929	0.905
Latency vs	(p)	<0.01	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
Blink Rate	a	6.860	6.191	7.133	2.962	7.619	2.705	2.090
@ Off	b	0.151	0.346	0.414	0.340	0.278	0.309	0.339
3 Blink Rate	r	-0.178	0.194	-0.760	0.019	0.126	0.412	0.228
@ Refix vs	(p)	NS	NS	(<0.02)	NS	NS	NS	NS
Blink Rate	a	18.021	14.228	89.092	19.356	16.855	-2.495	-8.201
@ Off	b	-0.213	-0.462	-2.889	0.069	0.279	1.077	1.378
4 Blink Rate	r	0.238	0.493	0.349	0.257	0.038	-0.179	-0.099
@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
Blink Rate	a	13.345	12.497	10.864	16.854	21.506	25.302	28.426
@ Off	b	0.559	2.087	1.997	1.292	0.194	-0.988	-1.084
5 TV Score	r	-0.081	0.327	-0.501	-0.159	-0.001	0.318	0.058
vs	(p)	NS	NS	NS	NS	NS	NS	NS
Blink Rate	a	2.911	5.536	9.073	3.103	4.869	5.099	6.099
@ On	b	-0.001	-0.001	-0.002	-0.001	0	0.001	0

continued/...

Table 35 A - Continued

	FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate	r	0.380	0.632	0.665	0.334	0.223	-0.201	0.140
	@ On vs	(p)	NS	(<0.05)	(<0.05)	NS	NS	NS	NS
	Response	a	39.555	14.076	-19.756	38.215	36.429	73.802	33.006
	Latency	b	4.854	6.810	8.173	4.693	3.471	-3.334	4.083
7	Blink Rate	r	-0.327	0.027	-0.043	0.270	0.081	-0.129	-0.184
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	5.267	4.941	9.210	-0.729	4.172	6.654	8.344
	@ On	b	-0.167	0.015	-0.029	0.194	0.035	-0.061	-0.102
8	TV Score	r	-0.307	-0.190	0.551	0.073	-0.212	-0.501	0.007
	vs	(p)	NS	NS	(<0.1)	NS	NS	NS	NS
	Blink Rate	a	14.883	20.242	20.346	18.907	20.496	21.825	21.756
	@ Refix	b	-0.002	-0.001	0.003	0	-0.002	-0.004	0
9	Response	r	0.150	0.025	-0.544	0.155	0.213	0.554	0.189
	Latency vs	(p)	NS	NS	NS	NS	NS	(<0.1)	NS
	Blink Rate	a	13.216	19.737	24.503	18.201	18.357	16.926	21.084
	@ Refix	b	0.023	0.004	-0.067	0.015	0.032	0.071	0.012
10	TV Score	r	-0.868	-0.854	-0.871	-0.900	-0.879	-0.897	-0.909
	vs	(p)	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001
	Response	a	61.533	57.999	60.520	63.670	65.175	69.249	72.422
	Latency	b	-0.033	-0.031	-0.037	-0.043	-0.044	-0.051	-0.056

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.02);
0.632 (0.05) ; 0.549 (0.1) ; not significant (NS).

Table 35B(I) : Correlation Analysis Results - Male Eyes (N = 34)

	FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
1	TV Score	r	-0.769	-0.935	-0.921	-0.767	-0.766	-0.953	-0.922
	vs	(p)	<0.01	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001
	Blink Rate	a	12.082	19.781	23.796	15.180	13.586	13.995	17.104
	@ Off	b	-0.006	-0.013	-0.018	-0.012	-0.013	-0.017	-0.018
2	Response	r	0.652	0.885	0.885	0.888	0.798	0.931	0.927
	Latency vs	(p)	<0.05	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
	Blink Rate	a	6.511	5.595	5.929	2.777	3.441	-0.456	3.236
	@ Off	b	0.130	0.363	0.438	0.297	0.305	0.308	0.274
3	Blink Rate	r	-0.047	-0.069	-0.009	0.245	-0.187	0.437	0.441
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	11.537	19.177	21.061	3.413	18.652	1.037	-13.304
	@ Off	b	-0.036	-0.103	-0.036	0.691	-0.351	0.777	1.828
4	Blink Rate	r	-0.094	-0.578	-0.063	0.398	-0.425	-0.040	0.671
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	(<0.05)
	Blink Rate	a	11.512	29.074	24.346	10.936	16.689	11.163	-0.872
	@ Off	b	-0.215	-3.229	-0.578	2.304	-2.503	-0.197	3.500
5	TV Score	r	-0.244	0.396	0.154	-0.242	0.315	0.144	-0.761
	vs	(p)	NS	NS	NS	NS	NS	NS	(<0.02)
	Blink Rate	a	1.769	3.429	6.608	0.995	0.848	1.169	4.724
	@ On	b	-0.001	0.001	0	-0.001	0.001	0.001	-0.003

continued/...

Table 35B(I): Continued

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate @ On vs Response Latency	r	0.436	-0.162	-0.014	0.278	-0.291	-0.255	0.853
		(p)	NS	NS	NS	NS	NS	NS	(<0.01)
		a	27.466	41.588	34.920	30.044	39.619	41.786	-24.634
		b	4.997	-2.456	-0.252	4.802	-4.485	-3.810	15.066
7	Blink Rate @ Refix vs Blink Rate @ On	r	-0.066	-0.276	-0.221	-0.161	0.216	-0.531	-0.006
		(p)	NS	NS	NS	NS	NS	NS	NS
		a	1.875	4.657	8.167	1.955	0.129	3.687	4.290
		b	-0.022	-0.066	-0.094	-0.078	0.069	-0.191	-0.005
8	TV Score vs Blink Rate @ Refix	r	-0.424	0.105	-0.205	-0.026	0.008	-0.548	-0.204
		(p)	NS	NS	NS	NS	NS	NS	NS
		a	11.225	16.183	16.182	13.838	12.860	13.716	15.047
		b	-0.004	0.001	-0.001	0	0	-0.006	-0.001
9	Response Latency vs Blink Rate @ Refix	r	0.174	-0.122	0.119	0.237	0.074	0.611	0.228
		(p)	NS	NS	NS	NS	NS	(<0.1)	NS
		a	8.942	17.461	15.487	12.845	12.344	8.518	14.245
		b	0.045	-0.034	0.015	0.028	0.015	0.114	0.016
10	TV Score vs Response Latency	r	-0.859	-0.866	-0.853	-0.909	-0.888	-0.908	0.925
		(p)	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001
		a	40.819	37.931	39.424	42.135	42.476	45.857	49.806
		b	-0.031	-0.029	0.034	-0.042	-0.041	-0.050	-0.062

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.02); 0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS)

Table 35B(II) : Correlation analysis results - Female Eyes (N = 16)

FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
1 TV Score	r	-0.395	-0.940	-0.816	-0.943	-0.656	-0.898	-0.876
vs	(p)	NS	<0.001	<0.01	<0.001	<0.05	<0.001	<0.001
Blink Rate	a	4.119	7.252	9.045	9.443	9.456	10.661	10.042
@ Off	b	-0.004	-0.015	-0.017	-0.020	-0.013	-0.019	-0.027
2 Response	r	0.694	0.841	0.825	0.921	0.705	0.896	0.815
Latency vs	(p)	<0.05	<0.01	<0.01	<0.001	<0.05	<0.001	<0.01
Blink Rate	a	0.648	0.546	1.315	0.614	3.938	3.260	-1.194
@ Off	b	0.177	0.317	0.360	0.398	0.240	0.308	0.474
3 Blink Rate	r	0.105	0.362	-0.799	-0.267	0.517	-0.031	-0.091
@ Refix vs	(p)	NS	NS	(<0.01)	NS	NS	NS	NS
Blink Rate	a	3.113	3.542	14.441	12.427	0.081	9.967	9.383
@ Off	b	0.171	0.669	-1.338	-0.906	1.145	-0.111	-0.216
4 Blink Rate	r	0.460	0.665	0.259	0.093	0.496	-0.213	-0.711
@ On vs	(p)	NS	(<0.05)	NS	NS	NS	NS	(<0.05)
Blink Rate	a	2.776	4.256	6.576	7.192	3.992	11.343	13.749
@ Off	b	0.827	1.015	0.508	0.256	1.141	-0.553	-3.056
5 TV Score	r	0.159	-0.472	-0.564	-0.011	-0.207	0.326	0.822
vs	(p)	NS	NS	(<0.1)	NS	NS	NS	(<0.01)
Blink Rate	a	1.135	2.092	2.462	2.090	4.006	3.899	1.447
@ On	b	0.001	-0.005	-0.006	0	-0.002	0.003	0.006

continued/...

Table 35B(II) : Continued

	FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate	r	0.077	0.698	0.686	0.333	0.483	-0.011	-0.679
	@ On vs	(p)	NS	(<0.05)	(<0.05)	NS	NS	NS	(<0.05)
	Response	a	17.073	12.320	11.356	13.448	5.665	19.211	28.770
	Latency	b	0.546	2.824	3.095	2.115	3.276	-0.81	-5.014
7	Blink Rate	r	0.492	-0.175	-0.459	0.133	-0.082	0.462	0.100
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	-0.527	2.422	3.952	1.229	4.414	-1.094	1.534
	@ On	b	0.448	-0.212	-0.391	0.165	-0.079	0.640	0.055
8	TV Score	r	0.449	-0.609	0.855	0.171	-0.581	0.129	0.114
	vs	(p)	NS	(<0.1)	(<0.01)	NS	(<0.1)	NS	NS
	Blink Rate	a	3.644	4.047	4.213	5.097	7.648	8.088	6.771
	@ Refix	b	0.003	-0.005	0.011	0.001	-0.005	0.001	0.002
9	Response	r	-0.208	0.321	-0.795	-0.107	0.339	-0.189	0.116
	Latency vs	(p)	NS	NS	(<0.01)	NS	NS	NS	NS
	Blink Rate	a	4.454	2.474	8.732	5.433	6.242	8.491	6.342
	@ Refix	b	-0.032	0.065	-0.207	-0.014	0.052	-0.018	0.029
10	TV Score	r	-0.880	-0.816	-0.886	-0.862	-0.857	-0.870	-0.850
	vs	(p)	<0.001	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01
	Response	a	20.720	20.031	21.053	21.483	22.665	23.382	22.747
	Latency	b	-0.038	-0.035	-0.043	-0.043	-0.050	0.053	-0.045

Critical Values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.02);
0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS)

Table 35C(I) : Correlation Analysis Results - Constant 6/4 Acuity Eyes (N = 38)

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
1	TV Score	r	-0.555	-0.959	-0.920	-0.876	-0.806	-0.930	-0.901
	vs	(p)	<0.1	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
	Blink Rate	a	10.657	19.574	27.805	19.945	21.178	19.463	22.226
	@ Off	b	-0.004	-0.015	-0.020	-0.016	-0.014	-0.020	-0.025
2	Response	r	0.717	0.886	0.911	0.923	0.875	0.937	0.906
	Latency vs	(p)	<0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Blink Rate	a	3.511	3.713	5.338	2.708	6.295	-0.081	-1.249
	@ Off	b	0.160	0.339	0.476	0.350	0.302	0.373	0.426
3	Blink Rate	r	-0.481	0.095	-0.627	-0.105	0.149	0.151	0.387
	@ Refix vs	(p)	NS	NS	(<0.1)	NS	NS	NS	NS
	Blink Rate	a	16.022	13.871	54.111	22.611	14.108	7.492	-14.755
	@ Off	b	-0.603	0.213	-2.031	-0.448	0.277	0.476	1.943
4	Blink Rate	r	0.509	0.333	0.193	0.357	0.036	-0.259	-0.376
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	7.677	14.303	15.084	12.457	17.571	22.848	36.269
	@ Off	b	1.693	1.510	1.077	1.904	0.161	-1.559	-4.132
5	TV Score	r	0.152	-0.187	-0.336	-0.253	0.060	0.305	0.394
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	1.200	1.621	8.04o	2.249	4.056	4.588	4.403
	@ On	b	0	-0.001	-0.001	-0.001	0	0.001	0.001

continued/...

Table 35C(I): Continued

			VISIT NO.						
	FACTOR PAIRING		0	1	2	3	4	5	6
6	Blink Rate	r	0.158	0.438	0.435	0.429	0.090	-0.310	-0.240
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Response	a	36.577	30.147	2.099	26.653	34.708	64.011	69.210
	Latency	b	2.371	5.195	4.629	6.033	1.168	-4.696	-5.601
7	Blink Rate	r	-0.817	0.516	0.076	0.188	-0.169	-0.191	-0.314
	@ Refix vs	(p)	(<0.01)	NS	NS	NS	NS	NS	NS
	Blink Rate	a	4.421	-1.709	7.087	-0.041	5.147	6.453	6.969
	@ On	b	-0.307	0.254	0.044	0.150	-0.070	-0.099	-0.144
8	TV Score	r	-0.295	-0.078	0.409	0.080	-0.268	-0.308	-0.054
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	10.615	12.711	14.505	13.866	15.405	16.942	16.538
	@ Refix	b	-0.002	-0.001	0.003	0	-0.003	-0.002	0
9	Response	r	0.075	0.056	-0.458	0.131	0.214	0.228	0.197
	Latency vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	9.735	12.234	17.913	13.490	13.315	15.317	15.679
	@ Refix	b	0.013	0.010	-0.074	0.012	0.040	0.029	0.018
10	TV Score	r	-0.845	-0.853	-0.883	-0.909	-0.892	-0.897	-0.906
	vs	(p)	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001
	Response	a	45.248	44.910	46.016	48.840	48.952	51.406	54.072
	Latency	b	-0.030	-0.034	-0.037	-0.045	-0.044	-0.049	-0.053

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (o.02);
0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS)

Table 35C(II): Correlation Analysis Results - Variable 6/4 Acuity Eyes (N = 12)

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
1	TV Score	r	-0.670	-0.746	-0.701	-0.641	-0.538	-0.883	-0.668
	vs	(p)	<0.05	<0.02	<0.05	<0.05	NS	<0.001	<0.05
	Blink Rate	a	5.543	7.473	5.136	4.860	4.843	5.213	4.909
	@ Off	b	-0.007	-0.010	-0.009	-0.010	-0.011	-0.010	-0.007
2	Response	r	0.583	0.610	0.706	0.770	0.487	0.785	0.742
	Latency vs	(p)	<0.1	<0.1	<0.05	<0.01	NS	<0.01	<0.02
	Blink Rate	a	3.217	3.071	1.922	0.640	1.644	2.669	3.012
	@ Off	b	0.137	0.321	0.214	0.281	0.187	0.136	0.104
3	Blink Rate	r	0.274	-0.185	-0.022	0.287	-0.111	0.403	0.167
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	3.819	8.813	4.813	2.364	6.142	3.477	3.424
	@ Off	b	0.309	-0.262	-0.032	0.384	-0.370	0.266	0.208
4	Blink Rate	r	-0.032	0.200	0.369	-0.019	-0.127	0.183	0.342
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	5.185	5.232	4.074	4.374	4.613	4.413	3.694
	@ Off	b	-0.048	0.441	0.640	-0.078	-0.512	0.388	0.541
5	TV Score	r	-0.278	-0.471	-0.396	0.248	-0.178	0.082	-0.449
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	1.705	3.923	1.023	0.847	0.814	0.548	1.693
	@ On	b	-0.002	-0.003	-0.003	0.001	-0.001	0	-0.003

continued/...

Table 35C(II) : Continued

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate	r	0.506	0.786	0.650	0.073	0.510	0.199	0.576
	@ On vs	(p)	NS	(<0.01)	(<0.05)	NS	NS	NS	(<0.1)
	Response	a	8.745	-0.438	9.441	12.321	9.734	13.045	4.589
	Latency	b	3.201	3.288	3.712	0.793	5.357	2.425	6.543
7	Blink Rate	r	0.255	-0.095	-0.421	-0.210	0.230	0.218	0.351
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	0.777	4.203	2.962	1.256	-0.231	0.276	0.072
	@ On	b	0.193	-0.061	-0.350	-0.070	0.192	0.068	0.276
8	TV Score	r	-0.194	-0.223	0.225	-0.093	0.056	-0.548	0.175
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	4.290	7.466	5.912	5.119	5.168	4.907	5.203
	@ Refix	b	-0.002	-0.002	0.002	-0.001	0	-0.009	0.001
9	Response	r	0.142	-0.178	-0.290	0.032	0.199	0.783	0.096
	Latency vs	(p)	NS	NS	NS	NS	NS	(<0.01)	NS
	Blink Rate	a	3.769	8.126	6.799	4.944	4.872	1.391	5.127
	@ Refix	b	0.030	-0.066	-0.061	0.009	0.023	0.206	0.011
10	TV Score	r	-0.885	-0.769	-0.800	-0.793	-0.818	-0.897	-0.889
	vs	(p)	<0.001	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001
	Response	a	16.255	13.055	14.553	14.920	16.286	17.818	18.289
	Latency	b	-0.041	-0.021	-0.035	-0.035	-0.043	-0.057	-0.064

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.02);
0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS)

Table 35D(I): Correlation Analysis Results - Total Spherical Refractive Errors (N = 24)

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
1	TV Score	r	-0.670	-0.970	-0.930	-0.891	-0.862	-0.928	-0.932
	vs	(p)	<0.05	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
	Blink Rate	a	7.170	13.988	19.628	14.307	14.918	13.517	14.939
	@ Off	b	-0.006	-0.020	-0.025	-0.017	-0.015	-0.018	-0.029
2	Response	r	0.763	0.875	0.901	0.939	0.873	0.923	0.903
	Latency vs	(p)	<0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Blink Rate	a	0.552	0.061	0.976	2.266	4.574	2.437	-2.643
	@ Off	b	0.246	0.490	0.653	0.406	0.332	0.331	0.509
3	Blink Rate	r	0.155	-0.238	-0.388	-0.183	0.346	0.245	0.257
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	5.177	16.604	34.266	18.165	8.033	3.547	-1.838
	@ Off	b	0.187	-0.600	-1.661	-0.613	0.464	0.684	1.332
4	Blink Rate	r	0.324	-0.277	-0.096	-0.445	0.040	-0.275	-0.369
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	5.685	12.419	18.393	15.452	12.379	14.758	21.998
	@ Off	b	0.821	-1.202	-0.505	13.143	0.137	-1.137	-5.567
5	TV Score	r	0.179	0.348	-0.086	0.292	0.068	0.330	0.499
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	0.821	0.570	4.301	0.995	3.086	3.015	1.804
	@ On	b	0.001	0.002	0	0.001	0	0.002	0.001

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Table 35D(I) : Continued

	FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate	r	0.225	-0.180	-0.007	-0.409	-0.163	-0.358	-0.369
	@ On vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Response	a	22.278	24.388	23.613	31.330	29.443	39.401	46.335
	Latency	b	1.768	-1.393	-0.051	-6.684	-1.488	-4.118	-9.881
7	Blink Rate	r	-0.590	0.030	-0.147	-0.124	-0.249	0.107	0.028
	@ Refix vs	(p)	(<0.1)	NS	NS	NS	NS	NS	NS
	Blink Rate	a	2.764	0.630	5.537	1.692	4.128	2.424	1.842
	@ On	b	-0.280	0.017	-0.119	-0.059	-0.096	0.072	0.010
8	TV Score	r	-0.312	0.223	0.294	-0.077	-0.328	-0.436	-0.037
	vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	6.947	8.299	10.601	10.135	10.901	11.449	9.832
	@ Refix	b	-0.002	0.002	0.002	0	-0.004	-0.003	0
9	Response	r	-0.037	-0.263	-0.283	0.016	0.188	0.200	0.329
	Lantency vs	(p)	NS	NS	NS	NS	NS	NS	N S
	Blink Rate	a	6.894	9.887	11.972	10.027	8.983	10.370	8.831
	@ Refix	b	-0.010	-0.058	-0.048	0.002	0.053	0.026	0.036
10	TV SCore	r	-0.808	-0.860	-0.889	-0.923	-0.900	-0.868	-0.882
	vs	(p)	<0.01	<0.01	<0.001	<0.001	<0.001	<0.01	<0.001
	Response	a	26. 663	27.269	27.860	29.522	30.569	32.438	33.446
	Latency	b	-0.024	-0.031	-0.034	-0.041	-0.042	-0.047	-0.048

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.02);
0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS)

Table 35D(II) : Correlation Analysis Results - Total Sphero-cylindrical Refractive Errors (N = 26)

FACTOR PAIRING			VISIT NO. 0	1	2	3	4	5	6
1	TV Score	r	-0.510	-0.805	-0.766	-0.825	-0.641	-0.919	-0.818
	vs	(p)	NS	<0.01	<0.01	<0.01	<0.05	<0.001	<0.01
	Blink Rate	a	9.027	13.070	13.247	10.398	11.180	11.148	12.278
	@ Off	b	-0.004	-0.008	-0.011	-0.013	-0.011	-0.017	-0.014
2	Response	r	0.570	0.746	0.812	0.946	0.687	0.875	0.829
	Latency vs	(p)	<0.1	<0.02	<0.01	<0.001	<0.05	<0.001	<0.01
	Blink Rate	a	5.676	6.510	5.300	0.718	3.010	0.550	4.436
	@ Off	b	0.096	0.206	0.239	0.283	0.232	0.281	0.199
3	Blink Rate	r	0.050	0.250	-0.712	0.279	0.188	0.345	0.178
	@ Refix vs	(p)	NS	NS	(<0.05)	NS	NS	NS	NS
	Blink Rate	a	8.240	8.530	27.525	4.767	5.611	2.757	2.999
	@ Off	b	0.035	0.300	-1.529	0.439	0.413	0.624	0.632
4	Blink Rate	r	-0.072	0.609	0.546	0.481	0.003	-0.027	0.033
	@ On vs	(p)	NS	(<0.1)	NS	NS	NS	NS	NS
	Blink Rate	a	8.823	7.924	6.255	6.352	9.626	9.177	10.042
	@ Off	b	-0.158	0.902	1.271	1.259	0.010	-0.135	0.123
5	TV Score	r	-0.306	-0.541	-0.535	-0.352	-0.100	0.102	-0.179
	vs	(p)	NS	NS	NS	NS	NS	NS	N S
	Blink Rate	a	2.094	4.974	4.800	2.134	1.816	2.111	4.294
	@ On	b	-0.001	-0.004	-0.003	-0.002	-0.001	0	-0.001

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Table 35D(II): Continued

	FACTOR PAIRING		VISIT NO. 0	1	2	3	4	5	6
6	Blink Rate	r	0.451	0.730	0.833	0.613	0.425	0.149	0.322
	@ On vs	(p)	NS	(<0.02)	(<0.01)	(<0.1)	NS	NS	NS
	Response	a	18.138	8.966	-1.542	18.199	22.220	24.763	9.571
	Latency	b	5.834	3.922	6.583	5.353	3.647	2.292	5.069
7	Blink Rate	r	0.298	-0.092	-0.484	0.389	0.289	0.165	-0.409
	@ Refix vs	(p)	NS	NS	NS	NS	NS	NS	NS
	Blink Rate	a	1.197	5.324	8.960	-0.234	-0.396	1.569	8.888
	@ On	b	0.097	-0.075	-0.447	0.234	0.218	0.060	-0.393
8	TV Score	r	-0.109	-0.448	0.593	0.046	0.046	-0.435	0.088
	vs	(p)	NS	NS	(<0.1)	NS	NS	NS	NS
	Blink Rate	a	7.938	11.931	9.762	8.865	9.714	10.422	11.908
	@ Refix	b	-0.001	-0.004	0.004	0	0	-0.005	0
9	Response	r	0.125	0.278	-0.616	0.230	0.222	0.632	-0.092
	Latency vs	(p)	NS	NS	(<0.1)	NS	NS	(<0.05)	NS
	Blink Rate	a	6.909	9.727	12.578	7.697	8.787	6.497	12.146
	@ Refix	b	0.030	0.064	-0.084	0.044	0.034	0.112	-0.006
10	TV Score	r	-0.896	-0.841	-0.856	-0.877	-0.860	-0.916	-0.921
	vs	(p)	<0.001	<0.01	<0.01	<0.001	<0.01	<0.001	<0.001
	Response	a	34.861	30.714	32.686	34.199	34.635	36.745	38.912
	Latency	b	-0.041	-0.031	-0.040	-0.044	-0.045	-0.054	-0.064

Critical values, Pearson r (8 df): 0.872 (0.001); 0.765 (0.01); 0.716 (0.2);
0.632 (0.05) ; 0.549 (0.1) ; Not Significant (NS).

Table 36: STUDY NO. 4 - Summary table, subjective ranked criteria.

Data for whole group of eyes (N = 50)

Three aspects of soft contact lens wear considered:

STABILITY OF VISION

1	Whole of time
2	Most of time
3	Half of time
4	Quarter of time
5	Virtually none of time

QUALITY OF VISION

1	Excellent
2	Good
3	Just acceptable
4	Poor
5	Very poor

COMFORT OF LENS

1	Excellent - lens not felt
2	Satisfactory
3	Fair
4	Poor
5	Intolerable

The choices listed in the Table are those indicated by the subjects on their questionnaire sheets (vide APPENDIX X; Figure 33, page 472) upon completion of data collection on each eye at the six soft contact lens visits.

Table 36:

SUBJECT Eye	No.	STABILITY - VISIT - 1	2	3	4	5	6	QUALITY - VISIT - 1	2	3	4	5	6	COMFORT - VISIT - 1	2	3	4	5	6
1	1	1	1	1	1	1	1	2	2	1	1	1	1	3	2	1	1	1	1
*2	1	2	2	2	2	2	1	3	3	2	2	2	2	3	2	1	1	1	1
*3	2	4	3	2	3	2	2	3	3	3	3	3	2	1	1	1	1	1	1
4	2	3	3	2	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1
*5	3	2	2	2	1	2	1	2	2	3	2	2	1	2	2	2	1	1	1
6	3	1	1	2	1	2	2	2	2	2	2	2	2	1	1	1	1	2	3
*7	4	2	1	1	1	1	-	1	1	1	1	1	-	2	2	2	3	3	-
8	4	2	1	1	1	1	-	1	1	1	1	1	1	2	2	2	3	2	2
*9	5	2	2	1	1	1	1	1	2	1	2	2	2	2	2	2	1	1	1
10	5	2	2	1	1	1	1	1	3	1	1	1	1	2	2	2	1	1	1
11	6	1	1	1	1	1	1	1	2	2	1	3	2	2	1	2	1	1	1
*12	6	1	1	1	1	1	1	2	3	3	2	2	2	3	2	2	1	1	1
*13	7	2	2	2	2	1	1	1	2	2	2	2	1	2	2	3	3	2	2
14	7	1	2	1	1	1	1	1	1	2	2	1	1	1	2	2	2	1	2
*15	8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
16	9	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
*17	9	2	1	1	2	2	2	3	2	2	2	2	2	2	2	1	1	1	1
*18	10	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	1	1	1
*19	10	2	2	2	2	2	1	2	2	2	2	2	1	1	1	1	1	1	1
20	11	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1
*21	11	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1
22	12	1	1	1	1	1	-	1	1	2	1	1	-	1	1	2	1	1	-
23	13	2	2	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1
24	13	2	2	2	1	2	2	1	1	1	1	1	1	2	2	2	2	1	1
25	14	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
26	14	2	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
27	15	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
28	15	2	2	2	2	2	2	2	2	2	2	2	1	2	3	2	2	2	2
29	16	2	2	3	2	2	2	2	2	2	1	2	1	2	2	2	2	2	2
30	16	2	2	3	3	-	2	2	2	2	2	-	1	3	3	2	2	-	3
31	17	2	2	1	2	2	2	2	2	1	1	1	1	2	2	2	1	1	1
32	17	2	2	1	2	2	1	2	2	1	1	1	1	2	2	1	1	1	1
33	18	2	2	2	2	2	1	1	1	1	2	2	1	2	2	2	2	2	2
34	18	2	2	2	2	2	1	1	1	1	2	2	1	2	2	2	2	2	2
35	19	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	1	1	1
36	19	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	1	1
37	20	1	1	2	2	2	2	2	1	2	1	2	1	1	1	1	1	1	1
38	20	1	1	2	2	2	1	2	1	2	1	1	1	1	1	1	1	1	1
39	21	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1
40	21	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1
41	22	2	1	1	1	1	1	2	2	2	2	2	2	1	1	2	2	2	2
42	23	2	1	2	2	2	2	2	2	2	2	2	2	3	2	2	2	3	2
43	23	2	2	2	1	1	2	2	2	2	2	2	2	3	2	2	2	2	2
44	24	2	2	2	1	1	1	2	2	2	2	2	2	2	1	2	1	1	1
45	25	2	1	1	2	2	2	2	2	2	2	2	2	3	1	2	3	2	3
46	25	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	3
47	25	2	2	2	2	1	2	1	1	1	1	1	1	2	2	1	1	1	2
48	26	2	2	2	2	1	2	1	1	1	1	1	1	2	2	2	1	1	2
49	27	2	2	2	2	2	-	2	1	1	1	1	-	1	1	1	1	1	-
50	27	1	2	2	2	2	-	1	1	1	1	1	-	1	1	1	1	1	-

All eyes attained a 6/4 (constant) acuity, except * 6/4 (variable).

Table 37: STUDY NO. 4 - Summary table, point biserial coefficient analysis.

Table 37A: Comparison - Subjective assessment of stability ($X = 0,1$)† of soft contact lens vision vs. the standard error of estimate ($Y = 0 \rightarrow \infty$)‡ associated with the best-fit linear regression line through the subjective TV score data*.

Table 37B: Comparison - Subjective assessment of quality ($X = 0,1$)† of soft contact lens vision vs. the gradient ($Y = 0 \rightarrow \infty$)‡ of the best-fit linear regression line through the subjective TV score data*.

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† Dichotomous variable (X): with reference to the data presented in Table 36: pages 405-406, classify subjective choices on the Stability and Quality ranked criteria scales of "1" as X = 0, and choices of "2", "3", ("4") as X = 1 (refer to Appendix VIID: page 459).

‡ Continuous variable (Y): the values of the standard error of estimate and gradients of the best-fit linear regression lines were obtained using the regression program Ref: JP2 (Appendix VIB: pages 435 to 438); full results are on file in the Soft Contact Lens Research Unit, Department of Ophthalmic Optics, The University of Aston in Birmingham.

* Subjective TV score data: mean of three runs, corrected for guessing (refer to Table 32: pages 315-328).

Table 37A(I): Whole group of eyes.

SOFT LENS VISIT NO.	COEFFICIENT r	df (2-sided)	SIGNIFICANCE LEVEL
1	0.329	48	⟨0.02
2	0.047	48	NS
3	0.064	48	NS
4	0.034	48	NS
5	0.073	47	NS
6	0.238	44	NS

Critical values, correlation coefficient r -

(50 df) : 0.433; 0.354; 0.322; 0.273; 0.231; not significant
(0.001) (0.01) (0.02) (0.05) (0.1) (NS)

(45 df) : 0.465; 0.372; 0.338; 0.288; 0.243; not significant

Table 37A(II): Sub-group of (variable acuity) eyes.

SOFT LENS VISIT NO.	COEFFICIENT r	df (2-sided)	SIGNIFICANCE LEVEL
1	0.244	10	NS**
2	0.497	10	⟨0.1
3	0.032	10	NS
4	0.232	10	NS
5	0.459	10	NS
6	0.428	9	NS

Critical values, correlation coefficient r -

(10 df) : 0.823; 0.708; 0.658; 0.576; 0.497; not significant
(0.001) (0.01) (0.02) (0.05) (0.1) (NS)

(9 df) : 0.847; 0.735; 0.685; 0.602; 0.521; not significant

** Full calculations relating to this particular set of data are presented (page 409) to illustrate the statistical procedure outlined in APPENDIX VIID: page 459, The Point Biserial Coefficient Analysis.

Calculations with reference to TABLE 37A(II) and APPENDIX VIID:

The Point Biserial Coefficient Analysis

Soft Lens Visit No. 1

Values of Y		Values of Y^2	
... @ X = 0	... @ X = 1	... @ X = 0	... @ X = 1
0.956	1.094	0.914	1.197
1.184	0.808	1.402	0.653
	0.548		0.300
	1.235		1.525
	0.405		0.164
	0.932		0.869
	1.127		1.270
	0.837		0.701
	1.084		1.175
	1.034		1.069
Σ 2.140	9.104	Σ 2.316	8.923
(n_o = 2)	(n_1 = 10)	(n_o = 2)	(n_1 = 10)

$$SS_T = (2.140)^2/2 + (9.104)^2/10 - (11.244)^2/12$$
$$= 2.290 + 8.288 - 10.536$$
$$= 0.042$$

$$SS_{tot} = 11.239 - (11.244)^2/12$$
$$= 0.703$$

$$r = \sqrt{0.042/0.703}$$
$$= 0.244$$

$$df = (n_o + n_1) - 2$$
$$= 12 - 2$$
$$= 10$$

Conclusion: For 10 df, r does not fall within tabled critical value.

Table 37B(I): Whole group of eyes.

SOFT LENS VISIT NO.	COEFFICIENT r	df (2-sided)	SIGNIFICANCE LEVEL
1	0.003	48	NS
2	0.131	48	NS
3	0.132	48	NS
4	0.347	48	<0.02
5	0.298	47	<0.05
6	0.292	44	<0.05

Critical values, correlation coefficient r -

(50 df) :	0.433; (0.001)	0.354; (0.01)	0.322; (0.02)	0.273; (0.05)	0.231; (0.1)	not significant (NS)
(45 df) :	0.465;	0.372;	0.338;	0.288;	0.243;	not significant

Table 37B(II): Sub-group of (variable acuity) eyes.

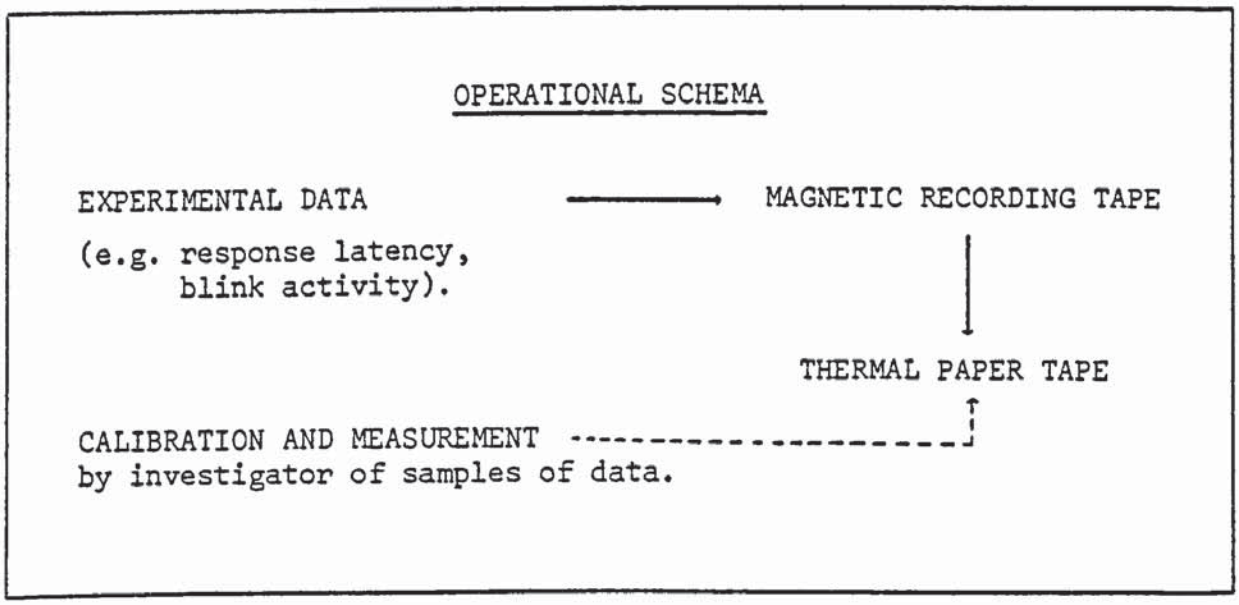
SOFT LENS VISIT NO.	COEFFICIENT r	df (2-sided)	SIGNIFICANCE LEVEL
1	0.158	10	NS
2	0.276	10	NS
3	0.304	10	NS
4	0.135	10	NS
5	0.286	10	NS
6	0.189	9	NS

Critical values, correlation coefficient r -

(10 df) :	0.823; (0.001)	0.708; (0.01)	0.658; (0.02)	0.576; (0.05)	0.497; (0.1)	not significant (NS)
(9 df) :	0.847;	0.735;	0.685;	0.602;	0.521;	not significant

Table 38: Study No 4 - An investigation of the accuracy of data production and measurement.

(Refer to Section 9.1A, pages 231 - 232).



It will be appreciated that there was a clear requirement to assess three features of the data production procedure:

A: To assess the measurement accuracy of the investigator.

B: To assess the constancy of data reproduction, (i.e. magnetic to paper tape).

C: To establish whether the proposed sampling of the experimental data would produce information as reliable as that which would be obtained using the whole of the available data.

The analyses summarised in Tables 38A - 38C indicate the measurement accuracy of the investigator, the (temporal) constancy of tape-to-tape data reproduction, and the validity of the 20% data-sampling procedure.

Table 38A, 38B : To facilitate investigation of investigator and tape accuracy, five reels of magnetic recording tape bearing experimental data from the study were selected at random. A single experimental run was identified, at differing positions, on each of the five reels, and a visible record produced on heat sensitive paper tape on three separate occasions, one week apart. Then, to assess investigator accuracy, the investigator measured three times a fixed sample of the response latency data of each of the five printed runs, as produced at the first printing session (Table 38A). To assess constancy of tape-to-tape reproduction, the measurements of a fixed sample of the response latency data of each of the five printed runs, as produced at the three printing sessions, were compared (Table 38B). One-way analyses of variance were undertaken on the results (Tables 38A, 38B).

Analysis failed to reveal any statistically significant results, thus indicating the accuracy of the investigator in measuring the experimental data, and also indicating the uniformity (on a temporal basis) of magnetic to paper tape reproduction of data.

Table No. 38A: To assess the measurement accuracy of the investigator.

Sample No.	Measurement	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	1st	1.5	1.0	1.2	1.0	0.6	1.1	1.1	0.8	1.2	1.4
		2.0	1.0	1.1	1.1	1.0	1.0	0.8	1.0	1.0	1.4
	2nd	1.5	1.0	1.1	1.0	0.6	1.0	1.1	0.8	1.2	1.4
		2.0	1.0	1.1	1.1	1.0	1.0	0.8	1.0	1.0	1.3
	3rd	1.5	1.0	1.1	1.0	0.6	1.0	1.1	0.8	1.2	1.4
		2.0	1.0	1.1	1.1	1.0	1.0	0.8	1.0	1.0	1.3
2	1st	1.0	1.0	1.2	0.7	1.0	1.0	0.7	0.6	0.6	0.8
		0.8	0.9	1.2	0.8	0.6	0.8	0.7	0.6	0.7	0.8
	2nd	1.0	1.0	1.2	0.7	1.0	1.0	0.7	0.7	0.6	0.8
		0.8	0.9	1.2	0.8	0.6	0.8	0.7	0.6	0.6	0.8
	3rd	1.0	1.0	1.3	0.7	1.0	1.0	0.7	0.6	0.6	0.8
		0.8	0.9	1.2	0.8	0.6	0.8	0.7	0.6	0.6	0.8
3	1st	1.4	1.7	2.2	1.4	1.6	2.0	1.2	1.1	1.4	1.6
		1.4	1.1	1.1	1.1	1.5	2.2	0.9	0.8	1.1	1.5
	2nd	1.4	1.6	2.2	1.4	1.6	2.0	1.1	1.1	1.4	1.6
		1.4	1.1	1.1	1.1	1.5	2.2	0.9	0.8	1.0	1.5
	3rd	1.4	1.7	2.2	1.4	1.6	2.0	1.1	1.1	1.4	1.6
		1.4	1.1	1.1	1.1	1.5	2.2	0.9	0.8	1.0	1.5
4	1st	0.9	1.1	1.0	1.0	1.1	1.0	0.9	0.8	1.1	0.8
		0.9	0.8	0.9	0.8	1.1	0.9	1.1	0.8	1.0	0.8
	2nd	0.9	1.0	1.0	1.0	1.1	1.0	0.9	0.8	1.1	0.8
		0.9	0.8	0.9	0.8	1.0	0.9	1.1	0.8	0.9	0.8
	3rd	0.8	1.0	1.0	1.0	1.1	1.0	0.9	0.8	1.1	0.8
		0.9	0.9	0.8	0.8	1.0	0.9	1.1	0.8	0.9	0.8
5	1st	2.2	1.8	0.9	0.8	1.1	1.3	0.8	0.9	2.0	2.2
		2.0	2.2	1.9	0.8	1.2	2.2	0.8	0.8	1.8	2.1
	2nd	2.2	1.8	0.9	0.8	1.1	1.3	0.8	0.9	2.0	2.2
		2.0	2.2	1.8	0.8	1.2	2.2	0.8	0.9	1.8	2.2
	3rd	2.2	1.8	0.9	0.8	1.1	1.3	0.8	0.9	2.0	2.2
		2.0	2.2	1.9	0.8	1.2	2.2	0.8	0.8	1.8	2.1

continued/...

Table 38A: continued

SUMMARY TABLE (one-way analysis of variance)-

	SOURCE	SUM SQUARES	df	MEAN SQUARES	F ‡
No. 1	BETWEEN - GROUPS	0.003	2	0.0015	0.017
	WITHIN - GROUPS	4.905	57	0.0861	
	TOTAL	4.908	59		
No. 2	BETWEEN - GROUPS	0.001	2	0.0005	0.013
	WITHIN - GROUPS	2.151	57	0.0377	
	TOTAL	2.152	59		
No. 3	BETWEEN - GROUPS	0.003	2	0.0015	0.010
	WITHIN - GROUPS	8.974	57	0.1574	
	TOTAL	8.977	59		
No. 4	BETWEEN - GROUPS	0.005	2	0.0025	0.198
	WITHIN - GROUPS	0.717	57	0.0126	
	TOTAL	0.722	59		
No. 5	BETWEEN - GROUPS	0.001	2	0.0005	0.001
	WITHIN - GROUPS	19.656	57	0.3448	
	TOTAL	19.657	59		

‡ F-ratio: Results not statistically significant
(tabled values, 2/57 df : $F_{0.01} = 5.01$,
$F_{0.05} = 3.17$)

Table No. 38B: To assess the constancy of the data reproduction.

Sample No.	Printing	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9
1	1st	1.5	1.0	1.2	1.0	0.6	1.1	1.1	0.8	1.2	1.4
		2.0	1.0	1.1	1.1	1.0	1.0	0.8	1.0	1.0	1.4
	2nd	1.5	1.0	1.1	1.0	0.7	1.0	1.1	0.8	1.2	1.5
		2.0	1.0	1.1	1.0	1.0	0.9	1.0	0.9	1.0	1.3
	3rd	1.5	0.9	1.1	0.9	0.6	1.1	1.0	0.8	1.2	1.4
		2.0	0.9	1.0	1.0	1.0	1.0	1.0	0.8	1.0	1.3
2	1st	1.0	1.0	1.2	0.7	1.0	1.0	0.7	0.6	0.6	0.8
		0.8	0.9	1.2	0.8	0.6	0.8	0.7	0.6	0.7	0.8
	2nd	0.9	0.9	1.3	0.7	1.0	1.1	0.7	0.6	0.6	0.7
		0.8	0.9	1.3	0.8	0.6	0.8	0.7	0.6	0.6	0.8
	3rd	0.9	1.0	1.3	0.7	1.0	1.1	0.7	0.6	0.6	0.8
		0.8	0.9	1.3	0.8	0.6	0.8	0.7	0.6	0.6	0.8
3	1st	1.4	1.7	2.2	1.4	1.6	2.0	1.2	1.1	1.4	1.6
		1.4	1.1	1.1	1.1	1.5	2.2	0.9	0.8	1.1	1.5
	2nd	1.4	1.7	2.1	1.4	1.6	2.1	1.1	1.1	1.5	1.6
		1.4	1.0	1.0	1.0	1.5	2.2	0.8	0.8	1.0	1.5
	3rd	1.4	1.7	2.1	1.4	1.7	2.1	1.1	1.1	1.4	1.7
		1.5	1.1	1.1	1.0	1.5	2.2	0.8	0.8	1.0	1.5
4	1st	0.9	1.1	1.0	1.0	1.1	1.0	0.9	0.8	1.1	0.8
		0.9	0.8	0.9	0.8	1.1	0.9	1.1	0.8	1.0	0.8
	2nd	0.9	1.1	1.0	0.9	1.0	0.9	0.8	0.7	1.1	0.8
		0.8	0.8	0.8	0.9	1.1	0.8	1.1	0.8	0.9	0.8
	3rd	0.9	1.1	1.0	0.9	1.0	0.9	0.8	0.8	1.1	0.9
		0.8	0.8	0.9	0.9	1.1	0.9	1.1	0.8	0.9	0.8
5	1st	2.2	1.8	0.9	0.8	1.1	1.3	0.8	0.9	2.0	2.2
		2.0	2.2	1.9	0.8	1.2	2.2	0.8	0.8	1.8	2.1
	2nd	2.2	1.8	1.0	0.8	1.1	1.3	0.8	0.8	2.0	2.2
		2.0	2.2	1.9	0.8	1.2	2.2	0.8	0.8	1.8	2.1
	3rd	2.2	1.9	0.9	0.8	1.1	1.3	0.8	0.8	2.0	2.2
		2.0	2.2	1.9	0.8	1.2	2.2	0.8	0.8	1.8	2.1

continued/...

Table 38B: continued

SUMMARY TABLE (one-way analysis of variance) -

	SOURCE	SUM SQUARES	df	MEAN SQUARES	F ‡
No. 1	BETWEEN - GROUPS	0.014	2	0.0070	0.081
	WITHIN - GROUPS	4.926	57	0.0860	
	TOTAL	4 940	59		
No. 2	BETWEEN - GROUPS	0.001	2	0.0005	0.012
	WITHIN - GROUPS	2.471	57	0.0434	
	TOTAL	2.472	59		
No. 3	BETWEEN - GROUPS	0.007	2	0.0035	0.021
	WITHIN - GROUPS	9.601	57	0.1684	
	TOTAL	9.608	59		
No. 4	BETWEEN - GROUPS	0.017	2	0.0085	0.616
	WITHIN - GROUPS	0.785	57	0.0138	
	TOTAL	0.802	59		
No. 5	BETWEEN - GROUPS	0	2	0	0
	WITHIN - GROUPS	20.074	57	0.3520	
	TOTAL	20.074	59		

‡ F-ratio: Results not statistically significant
(tabled values, 2/57 df : $F_{0.01} = 5.01$, $F_{0.05} = 3.17$)

Table 38C: In order to facilitate handling and analysis of data produced in Study No. 4, a 20% fixed sampling procedure was suggested to reduce the data volume:

		CYCLE									
		1	2	3	4	5	6	7	8	9	10
	0					X	X				
S	1				X			X			
T	2			X					X		
I	3		X							X	
M	4	X									X
U	5	X									X
L	6		X							X	
U	7			X					X		
S	8				X			X			
	9					X	X				

(X = sampling point)

To assess the validity, on a statistical basis, of such a procedure the experimental results (i.e. response latency and blink activity) on three separate occasions of four eyes (two male, two female) were selected at random from the mass of data generated over the period of the study. Parallel with the determination of mean data averaged over all ten presentation cycles of each stimulus size in a run, sampled values averaged over only two presentations (vide supra) were also produced (Table 38C). Two-tailed Student t-tests were then undertaken upon the two data sets (Table 38C).

Analysis consistently failed to reveal any statistically significant differences between the whole run and sampled data sets, thus indicating the validity of the specific 20% data-sampling procedure as a suitable approach to the reduction of the volume of data produced by the full experiment.

Table 38C(I): Investigation of data-sampling procedure - Response latency data.

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
A (22)	I	$\bar{x}_{10}$	1.30	1.30	0.98	0.80	1.18	1.32	0.66	0.62	1.20	1.34	+0.432	18	$p > 0.20$
		x_2	1.40	1.20	0.80	0.80	1.00	1.60	0.70	0.50	0.90	1.20			
	II	$\bar{x}_{10}$	1.37	1.42	0.88	0.80	1.30	1.25	0.70	0.62	1.21	1.34	-0.476	18	$p > 0.20$
		x_2	1.55	1.60	0.85	0.90	1.50	1.35	0.80	0.65	1.00	1.40			
	III	$\bar{x}_{30}$	1.38	1.33	1.09	0.87	1.35	1.18	0.74	0.67	1.27	1.35	+0.536	18	$p > 0.20$
		x_6	1.40	1.23	0.87	0.93	1.13	1.13	0.77	0.70	1.13	1.27			
B (24)	I	$\bar{x}_{10}$	0.91	0.96	0.98	0.72	1.10	1.02	0.66	0.65	0.86	0.88	+0.294	18	$p > 0.20$
		x_2	0.95	0.95	1.10	0.65	1.05	0.90	0.70	0.75	0.75	0.70			
	II	$\bar{x}_{10}$	0.89	0.71	0.94	0.83	0.93	0.94	0.77	0.73	0.78	0.88	-0.952	18	$p > 0.20$
		x_2	0.85	0.80	0.85	1.00	0.85	0.80	0.95	0.75	0.80	1.15			
	III	$\bar{x}_{30}$	0.77	0.83	0.88	0.84	0.97	0.89	0.77	0.76	0.80	0.82	+0.476	18	$p > 0.20$
		x_6	0.73	0.85	0.83	0.82	0.85	0.83	0.82	0.78	0.78	0.87			

continued/...

Table 38C(I): Continued

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
C (26)	I	$\bar{x}_{10}$	1.15	1.16	1.06	0.91	1.01	1.09	0.85	0.85	0.96	0.95	-0.374	18	p>0.20
		$\bar{x}_{2}$	1.55	1.25	0.90	0.90	0.90	0.90	0.80	0.85	1.20	1.00			
	II	$\bar{x}_{10}$	1.03	1.36	1.09	0.90	1.37	1.18	0.91	0.83	1.27	1.24	-0.351	18	p>0.20
		$\bar{x}_{2}$	0.90	1.60	1.35	0.85	1.55	0.90	0.85	0.90	1.35	1.30			
	III	$\bar{x}_{30}$	0.98	1.02	1.01	0.87	0.95	1.01	0.83	0.80	0.93	0.91	0	18	p>0.20
		$\bar{x}_{6}$	1.15	1.02	0.93	0.83	0.93	0.92	0.82	0.78	1.00	0.95			
D (29)	I	$\bar{x}_{10}$	1.14	1.21	1.33	1.04	1.25	1.41	0.87	0.68	1.20	1.26	+0.089	18	p>0.20
		$\bar{x}_{2}$	1.05	1.00	1.55	1.35	1.00	1.40	0.95	0.60	1.05	1.30			
	II	$\bar{x}_{10}$	1.76	1.84	1.23	1.20	1.80	1.39	1.04	1.06	1.89	1.93	+0.181	18	p>0.20
		$\bar{x}_{2}$	1.80	1.75	1.45	1.05	1.80	1.10	1.20	0.95	1.65	2.05			
	III	$\bar{x}_{30}$	1.70	1.73	1.23	1.08	1.58	1.36	1.05	0.96	1.67	1.73	0	18	p>0.20
		$\bar{x}_{6}$	1.83	1.73	1.28	1.05	1.47	1.32	1.03	0.87	1.63	1.93			

All tests not statistically significant, p>0.20 : tabled value (18df, 2-tailed testing) = 1.330

Table 38C(II): Investigation of data-sampling procedure - Blink rate at refixation data.

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
A (22)	I	$\bar{x}_{10}$	0.82	0.73	0.46	0.82	0.73	0.73	0.82	0.82	0.46	0.64	-0.878	18	p > 0.20
		$\bar{x}_{2}$	0.91	0.46	0.46	0.91	0.91	0.91	0.91	0.91	0.46	0.91			
	II	$\bar{x}_{10}$	0.46	0.73	0.64	0.73	0.64	0.64	0.36	0.64	0.55	0.46	-0.500	18	p>0.20
		$\bar{x}_{2}$	0.46	0.46	0.91	0.91	0.91	0.91	0.46	0.46	0.91	0			
	III	$\bar{x}_{30}$	0.67	0.52	0.49	0.61	0.55	0.49	0.58	0.67	0.46	0.58	-1.550	18	p>0.10
		$\bar{x}_{6}$	0.76	0.76	0.61	0.61	0.46	0.46	0.61	0.91	0.46	0.91			
B (24)	I	$\bar{x}_{10}$	0	0.09	0	0.18	0.09	0.18	0	0	0	0	+2.250	18	p>0.02
		$\bar{x}_{2}$	0	0	0	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0.27	0.27	0.36	0.36	0.36	0.36	0.36	0.27	0.27	0.73	-0.327	18	p>0.20
		$\bar{x}_{2}$	0.91	0	0	0	0.91	0.91	0.46	0	0	0.91			
	III	$\bar{x}_{30}$	0.24	0.21	0.27	0.42	0.18	0.27	0.27	0.15	0.18	0.33	+0.173	18	P>0.20
		$\bar{x}_{6}$	0.30	0.15	0	0.30	0.30	0.46	0.15	0	0.30	0.46			

continued/...

Table 38C(II): Continued

Eye No..	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
C (26)	I	$\bar{x}_{10}$	0.09	0.09	0.09	0.27	0.09	0	0	0.09	0.09	0	-0.166	18	p>0.20
		$\bar{x}_2$	0.46	0	0.46	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0.36	0.55	0.46	0.46	0.46	0.55	0.46	0.55	0.36	0.27	+0.325	18	p>0.20
		$\bar{x}_2$	0.46	0.91	0.91	0	0.46	0.46	0	0	0.46	0.46			
	III	$\bar{x}_{30}$	0.12	0.03	0.03	0.09	0.15	0.03	0.03	0.09	0.09	0.06	-0.935	18	p>0.20
		$\bar{x}_6$	0.15	0	0.15	0	0.30	0.15	0	0.15	0.15	0			
D (29)	I	$\bar{x}_{10}$	0.09	0	0	0	0.09	0	0	0.09	0	0	-0.395	18	p>0.20
		$\bar{x}_2$	0	0	0	0	0	0	0	0.46	0	0			
	II	$\bar{x}_{10}$	0.46	0.55	0.64	0.36	0.73	0.55	0.36	0.55	0.46	0.18	+0.612	18	p>0.20
		$\bar{x}_2$	0	0	0.46	0.46	0.91	0.91	0.46	0.46	0.46	0			
	III	$\bar{x}_{30}$	0.18	0.36	0.52	0.30	0.36	0.36	0.36	0.39	0.39	0.30	+0.512	18	p>0.20
		$\bar{x}_6$	0.15	0	0.46	0.30	0.46	0.30	0.30	0.61	0.46	0.15			

All tests not statistically significant : tabled values (18 df, 2-tailed testing) p(0.20)= 1.330;
p(0.10)= 1.734;
p(0.02)= 2.552.

Table 38C(III): Investigation of data-sampling procedure - Blink rate at stimulus on data.

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
A (22)	I	$\bar{x}_{10}$	0.10	0.08	0.10	0.53	0	0.05	0	0	0.06	0.22	+ 1.091	18	p > 0.20
		x_2	0	0.42	0	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0.20	0.34	0.21	0.66	0.31	0.23	0.35	0.87	0.18	0.34	- 0.003	18	p > 0.20
		x_2	0.65	0.36	0	0	0	0	0.50	1.55	0.42	0.71			
	III	$\bar{x}_{30}$	0.25	0.23	0.29	0.49	0.10	0.19	0.32	0.38	0.13	0.18	+ 1.138	18	p > 0.20
		x_6	0.26	0.24	0.49	0.21	0.21	0	0	0.17	0.11	0.21			
B (24)	I	$\bar{x}_{10}$	0	0	0	0	0	0	0	0	0	0	0	18	p > 0.20
		x_2	0	0	0	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0	0	0	0	0	0	0	0	0	0	0	18	p > 0.20
		x_2	0	0	0	0	0	0	0	0	0	0			
	III	$\bar{x}_{30}$	0	0	0	0	0	0	0	0	0	0.04	- 0.773	18	p > 0.20
		x_6	0	0	0	0	0	0	0	0	0	0.19			

continued/...

Table 38C(III) : continued

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
C (26)	I	$\bar{x}_{10}$	0	0	0	0	0	0	0	0	0	0	0	18	$p > 0.20$
		x_2	0	0	0	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0.08	0.08	0.24	0	0.37	0.06	0.22	0.13	0.07	0.13	- 0.910	18	$p > 0.20$
		x_2	0	0	0.33	0	0.33	0	0.55	0.63	0	0.32			
	III	$\bar{x}_{30}$	0	0	0	0	0	0	0.09	0	0	0	- 0.783	18	$p > 0.20$
		x_6	0	0	0	0	0	0	0.45	0	0	0			
D (29)	I	$\bar{x}_{10}$	0	0	0	0	0	0	0	0	0	0	0	18	$p > 0.20$
		x_2	0	0	0	0	0	0	0	0	0	0			
	II	$\bar{x}_{10}$	0.21	0.06	0	0.09	0	0.07	0.06	0.13	0	0.05	- 0.324	18	$p > 0.20$
		x_2	0.56	0.32	0	0	0	0	0	0	0	0			
	III	$\bar{x}_{30}$	0.17	0.06	0.03	0.05	0.02	0.09	0.09	0.10	0.02	0.07	- 0.393	18	$p > 0.20$
		x_6	0.34	0.11	0	0.12	0	0.11	0	0	0	0.17			

All tests not statistically significant, $p > 0.20$: tabled value

(18 df, 2-tailed testing) = 1.330

Table 38C(IV): Investigation of data-sampling procedure - Blink rate at stimulus off data.

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
A (22)	I	$\bar{x}_{10}$	0.07	0.07	0.07	0	0	0.13	0.07	0	0.13	0.13	- 0.850	18	$p > 0.20$
		$\bar{x}_2$	0	0	0	0	0	0.33	0	0	0	0.33			
	II	$\bar{x}_{10}$	0	0	0	0	0	0	0	0	0	0	0	18	$p > 0.20$
		$\bar{x}_2$	0	0	0	0	0	0	0	0	0	0			
	III	$\bar{x}_{30}$	0.05	0.09	0.05	0	0.07	0.07	0.07	0.07	0.13	0.09	- 0.229	18	$p > 0.20$
		$\bar{x}_6$	0	0	0	0	0.33	0.11	0.11	0	0.11	0.11			
B (24)	I	$\bar{x}_{10}$	0.07	0.07	0.13	0.07	0.13	0.07	0.07	0.07	0.27	0	+ 0.586	18	$p > 0.20$
		$\bar{x}_2$	0	0.33	0	0	0	0	0	0	0.33	0			
	II	$\bar{x}_{10}$	0.13	0	0.20	0.07	0.07	0.13	0	0	0	0	- 0.099	18	$p > 0.20$
		$\bar{x}_2$	0	0	0	0	0	0.67	0	0	0	0			
	III	$\bar{x}_{30}$	0.09	0.02	0.11	0.07	0.07	0.13	0.02	0.04	0	0.07	+ 0.249	18	$p > 0.20$
		$\bar{x}_6$	0.11	0	0	0.11	0	0.22	0	0	0	0.11			

continued/...

Table 38C(IV): continued

Eye No.	Data	Set	STIMULUS NO. 0	1	2	3	4	5	6	7	8	9	Student t-ratio	df (2-sided)	Signif. Level
C (26)	I	$\bar{x}_{10}$	0.13	0.34	0.34	0.13	0.20	0.27	0.34	0.13	0.40	0.13	+ 1.167	18	$p > 0.20$
		x_2	0.33	0	0.33	0	0.33	0.33	0.33	0	0	0			
	II	$\bar{x}_{10}$	1.14	1.14	0.54	0.67	0.80	0.60	0.54	0.54	1.14	0.94	- 0.213	18	$p > 0.20$
		x_2	1.34	0.67	0.67	0.67	0.67	0.67	0.33	0.67	1.33	1.33			
	III	$\bar{x}_{30}$	0.20	0.27	0.29	0.16	0.13	0.18	0.16	0.25	0.27	0.11	+ 0.883	18	$p > 0.20$
		x_6	0.11	0.11	0.45	0	0.11	0.11	0.11	0.11	0	0			
D (29)	I	$\bar{x}_{10}$	0.20	0.20	0	0	0.07	0.07	0	0.13	0	0.20	- 0.208	18	$p > 0.20$
		x_2	0.33	0	0	0	0	0.33	0	0	0	0.33			
	II	$\bar{x}_{10}$	0	0	0.07	0	0	0	0	0.07	0	0.07	- 0.345	18	$p > 0.20$
		x_2	0	0	0.33	0	0	0	0	0	0	0			
	III	$\bar{x}_{30}$	0	0.04	0.07	0	0	0.02	0	0.04	0	0.02	- 0.180	18	$p > 0.20$
		x_6	0	0	0.11	0	0	0.11	0	0	0	0			

All tests not statistically significant, $p > 0.20$: tabled value

(18 df, 2-tailed testing) = 1.330

APPENDIX V

The Quantification of Visual Performance
including a description of the procedure for
The Correction of Raw Data for Guessing

As has been described in Section 4.3C (pages 113-114), by direct observation of the coloured light display on the TV system's control panel the investigator was able to note on the special recording charts (Figure 27, page 427):

(i) The position of the break (denoted thus: •) in each stimulus presented to the subject.

(ii) The position of the subject's response, whether it was correct (denoted thus: /) or erroneous (denoted thus: X).

On completion of data collection at an experimental session, for each run undertaken (comprising one hundred stimulus presentations, i.e., ten random presentations of each of the ten stimuli) the total number of correct responses for each stimulus size were obtained by totalling along each row (Figure 27, page 427). Then as is the accepted procedure when testing in this manner with this type of stimulus (vide e.g., Prince and Fry 1956, 1958, Flom et al. 1963, Davidson and Eskridge 1977), these raw data totals were corrected for guessing.

Figure 27: An example of the manual recording chart used in the work reported herein to register TV stimulus and subject response data.

Subject: Date:

App. . . . . B-on-W/ W-on-B
Inter. . . . . Contrast. . . .

Eye: V.A.:

Run Nº

SIZE 0 1 2 3 4 5 6 7 8 9

CYCLE 0 1 2 3 4 5 6 7 8 9

raw SUB-TOT. corrected PROB.

totals 'perf.'

presented correct(&%)

MEAN -corr.

The mathematical transformation used in all of the experimental work reported herein to 'correct' raw scores for guessing was a procedure outlined by Prince and Fry (1956, 1958). The transformation is applicable to four orientation testing where there is preferably an approximately equal number of presentations in all four meridians over a given run.

It will be appreciated that for each individual stimulus size, the total raw score of a run represents the number of times that the broken ring of a given size is called correctly. It is assumed that the number called correctly includes the number seen correctly and one-quarter of the remainder, which are called correctly by guessing.

These facts can be expressed in the form of an equation:

$$N_c = N_s + 1/4 \ (N - N_s) \qquad \ldots\ldots \text{(1a)}$$

Here N_c represents the number called correctly, N_s represents the number actually seen, and N represents the number of presentations of a given stimulus size in a run (equal to 10 in all of the experimental work reported herein).

Therefore in expanded form:

$$N_c = 3/4 \ N_s + 1/4 \ N \qquad \ldots\ldots \text{(1b)}$$

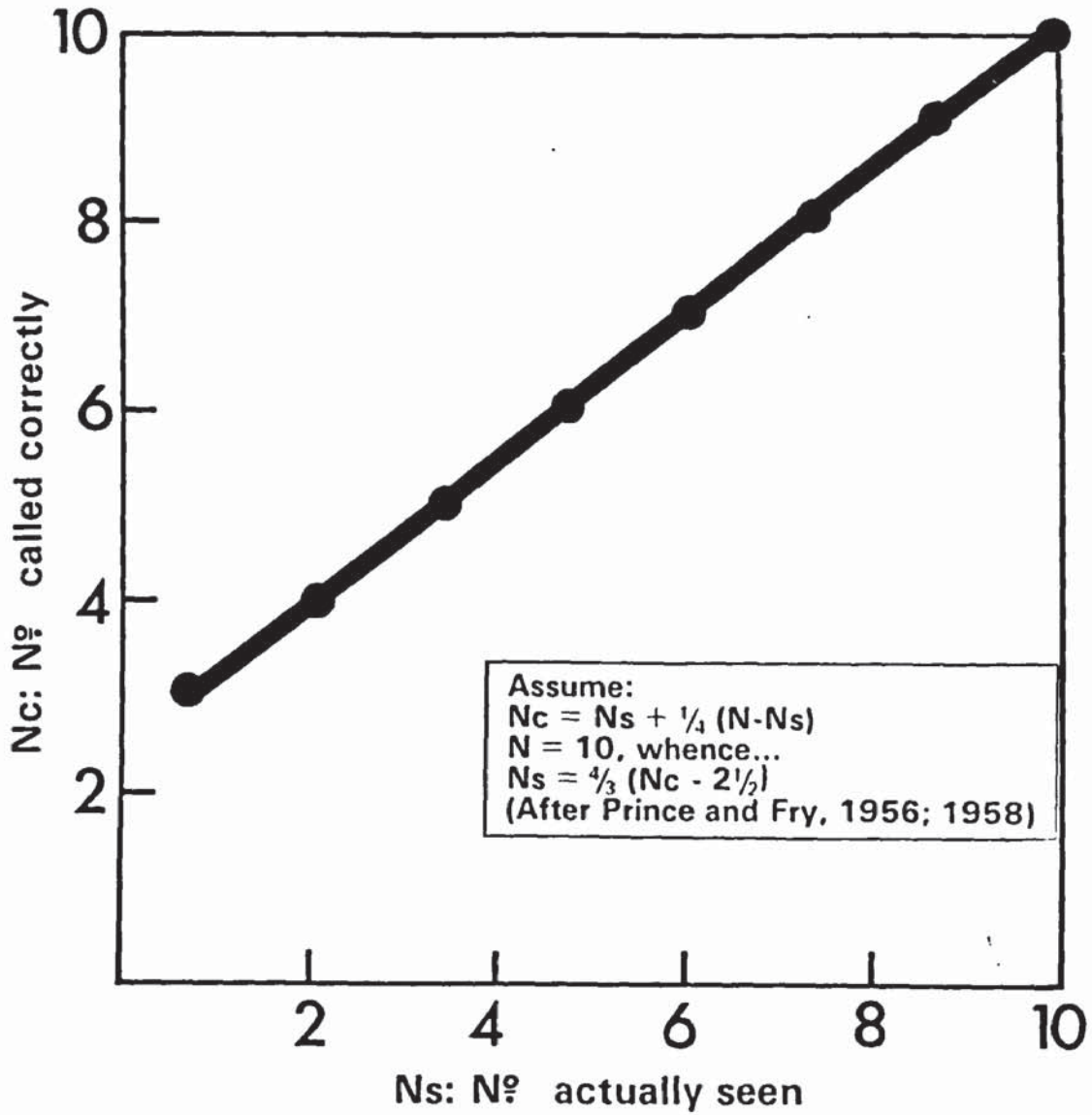
Whence:

$$N_s = 4/3 \ (N_c - 1/4N) \qquad \ldots\ldots \text{(2)}$$

Figure 28: The correction of raw scores for guessing: a graphical representation of the derived mathematical transformation.

(after Prince and Fry 1956, 1958).

CORRECTION OF SCORES FOR GUESSING



This equation (2), graphically presented in Figure 28 (page 429), is based upon the assumption that when the position of the break is not actually seen, the subject guesses its position and has a twenty-five per cent chance of guessing correctly. This assumption is no doubt an over-simplification because there must be instances where the subject can detect that the break is, for example, not up or down but cannot tell whether it is left or right. (This pattern of response could occur when uncorrected astigmatism was present).

Visual performance was specified in quantitative terms by a consideration of a subject's correct scores for each of the test stimuli, usually averaged over several runs. As has been demonstrated (Pointer et al. 1980b, 1981) a sigmoid curve represented the results of each run undertaken with the TV system. From a consideration of the best-fit linear regression line (method of least squares) through those points lying within the central portion of the curve, visual performance could be specified in terms of the threshold acuity level and the variability of vision. A computer program was prepared, Ref: JP2 (listed in Appendix VIB, page 438), specifically to facilitate such an analysis.

Further details and illustrative examples of this procedure, incorporating data obtained under experimental conditions, are provided in Pointer et al. (1980b, 1981). For ease of reference, copies of these published papers are furnished in supporting literature bound at the rear of this volume, (Appendix XV, pages 514-529).

APPENDIX VI

Computer Programs

Program listings and notes

relevant to the computing procedures.

APPENDIX VIA

Application Program Ref: UA31

(University of Aston/Applied Psychology)

Analysis of Variance Program

Language : 1900 ICL ALGOL

The program is a general analysis of variance program, devised to handle balanced and factorial designs up to N ways. Equal numbers are required in the cells. According to its writer*, this program has been devised for analysis of large designs without the sophistication normally required to run a computer library statistical package.

A program listing was not available for inclusion here, but some notes are appended in connection with the preparation of data for submission to the program. Further details should be obtained from the program's writer* at the address given below.

The experimental data should be punched onto cards, paying attention to the following parameters which are necessary to define the model and the layout of results:

1. Number of separate data sets to be analysed. If there is only one then a 1 must be punched here. The program will perform separate analyses on any number of data sets with different models, each of which must be preceded by the following parameters.

---

* Dr P Hudson, Psychological Laboratory, St. Andrews University, Scotland.

2. Number of factors (K). If there is more than one subject per cell then subjects must be included as a factor here.

3. Number of repeated measures (RM). This must be less than K. Several models are available - in all the work reported herein, Model No. 1 (RM = K-1) was used. This produced a completely crossed design, i.e., all subjects found over all levels of all factors. The error term used for the F-ratios is the individual within-subject mean square (e.g., the error term for A X C is A X C X S).

4. Levels list. A set of K integers (all greater than one). The number of levels on each of the K factors. The first number defines the number of levels on factor A, the second on factor B, etc. (As a check, the product of these numbers must be equal to the number of data points). Subjects must always be declared last.

5. Order list. A set of K integers. This list enables the investigator to define, with the levels list, the arrangement of the data in the data set. The first number refers to the slowest cycling factor subscript in the data as set out on the punched cards. The sequence in the order list is from the slowest to the fastest cycling factor; e.g., if B is the slowest cycling factor then the first number in the order list is 2, this number being the position on the levels list of the slowest cycling factor. If the second slowest factor is A, then the order list would start 2 1, etc.

6(a) Means required. K integers of value 0 or 1; 1 = means required over this factor, 0 = no means. So, for example, in a five factor experiment, if means are wanted over factors A, B, D but not C or E (subjects) then the values input are 11010: this would give all means with these factors but not A X B X C means, for example.

6(b) A control integer for transformations. A choice of several transformations (integers) are available, but in all the work reported herein integer 0, (i.e., no transformations) was used.

6(c) Name of experimental data to be analysed. This should be punched in instring quotes, e.g. '('experiment number 4')'.

7. Data. To be submitted in the sequence defined by the levels and order lists.

APPENDIX VIB

Program Ref: JP2

Linear Regression Analysis

Language : HP 2000 BASIC

The technique of probit analysis (Finney 1971) is often utilised to examine the sigmoid curves produced by a psychophysical test procedure. However, this method was felt to be too prolix an approach in the present work : a procedure was required for routine use which would facilitate rapid correlation of stimulus (minimum angle of resolution, min arc) and response ('corrected' TV scores) data.

Reference to the published work of Davidson and Eskridge (1977) in the field of vision testing established that it would be in order to fit the experimental data linearly by the method of least squares, with certain provisos:

(i) In order that the best-fit straight line should be a close approximation to the best sigmoid-shaped curve through the experimental results, it would be necessary to discard those data points that corresponded to 0% and 100% correct- if this was not done, the best fitting straight line would be much flatter than the data warranted.

(ii) It would be required that a set of results have a minimum of three data points remaining, after the absolute minimal and maximal values have been discarded, for them to be included in the data analysis (this provision may eliminate some data sets from analysis, note).

A linear regression program (Ref: JP2) was thus written for particular application in the work reported herein. Reference to the program listing (page 438) will indicate that data was required to be submitted in (X, Y) pairs: X values (stimulus) were plotted along the abscissa, and Y values (response) were plotted along the ordinate. To minimise the risk of operator error, several traps were written into the program. These provided an automatic check on the number of data pairs which had been input and, by producing a display of the input data, required positive action on the part of the operator to initiate the calculation stages of the program.

As has been mentioned in Appendix V (page 430), and illustrated in the papers of Pointer et al. (1980b, 1981), visual performance was specified, on the basis of the regression analysis, in terms of the resulting threshold acuity level and the degree of variability of vision. The threshold value was set at Y = 6.25; by convention, correct subjective responses to at least five of the eight test letters (i.e., 62.5%) on each of the lower lines of the optometric test chart are usually taken to establish the individual's acuity level. The variability of vision was indicated by the slope of the regression line, the first standard error of estimate associated with it, and

the Pearson product-moment correlation coefficient (r). The remarks upon repeatability of subjective scoring made in Section 7.4Avi (page 197) should be noted in connection with the results of the regression analysis.

```
LIST
JP2


 10    PRINT "TYPE IN NO. OF X, Y PAIRS"
 20    INPUT N
 30    PRINT "TYPE IN X AND Y VALUES ALONG LINE"
 35    DIM A£ (5)
 40    MAT  INPUT A(N,2)
 50    MAT  PRINT A
 55    PRINT
 60    PRINT "ARE VALUES CORRECT?"
 65    INPUT A£
 70    IF A£="YES" THEN 85
 80    GOTO  30
 85    PRINT
 90    PRINT "OK RUNNING"
 92    LET S1=S2=T=U=V=0
 95    FOR I=1 TO N
100    LET S1=S1+A(I,1)
110    NEXT I
120    LET M1=S1/N
130    FOR I=1 TO N
140    LET T=T+(A(I,1)-M1)  ** 2
150    NEXT I
160    FOR I=1 TO N
170    LET S2=S2+A(I,2)
180    NEXT I
190    LET M2=S2/N
195    FOR I=1 TO N
200    LET U=U+(A(I,2)-M2) ** 2
210    NEXT I
215    FOR I=1 TO N
220    LET V=V+(A(I,1)-M1)*(A(I,2)-M2)
222    NEXT I
225    LET R=V/(SQR(T*U))
230    PRINT "SLOPE OF Y ON X REGRESSION LINE IS";V/T
240    PRINT
250    PRINT "SLOPE OF X ON Y REGRESSION LINE IS";V/U
260    PRINT
270    PRINT "PEARSON CORRELATION COEFFICIENT IS";R
280    PRINT
290    PRINT "S.E. (Y) =";SQR(U/N)*(SQR(1-R ** 2))
300    PRINT
310    PRINT "S.E. (X) =";SQR(T/N)*(SQR(1-R ** 2))
320    PRINT
330    LET X1=M1+R*((SQR(T/N))/(SQR(U/N)))*(6.25-M2)
340    PRINT "50% THRESHOLD ACUITY =";X1;"SNELLEN ACUITY = 6/";6*X1
400    END
```

APPENDIX VIC

Program Ref: JP VIS

Sum Correlation Analysis

Language : Fortran II

A correlation/linear regression program (Ref: JP VIS) was written to facilitate analysis of data generated by Study No. 4. The complete experimental data were required to be typed into the computer to establish a matrix of results in the latter's memory store (data disc Ref: RXA1), thereby facilitating the subsequent pairwise correlation of factors (vide Table 17, page 235).

Five factors were to be handled:

(i)	'TV SCORE'	(correct subjective responses)
(ii)	'REACTION TIME'	(response latency)
(iii)	'BLINK REFIX'	(blink rate at refixation)
(iv)	'BLINK ON'	(blink rate while stimulus presented)
(v)	'BLINK OFF'	(blink rate when stimulus off)

The dimension of each factor was identical, viz, (10,7): i.e., ten levels (TV stimulus sizes) over seven visits (data collection session 0: best spectacle correction, data collection sessions 1-6: optimum soft contact lens).

Each of the fifty eyes in the study was given an individual file name: this comprised a four-letter code, being the first three letters of the subject's surname suffixed by 'R' (right) or 'L' (left).

The block of experimental data for each eye, under the five factor headings (vide data, Appendix IV: Tables 32 -34, pages 315-389) was typed into the computer. Where there were missing data points a dummy argument (viz, '1.0') was typed in. To minimise the risk of a typing error, the operator maintained a constant interaction with the data he was inputting courtesy of a subroutine program, Ref: RECOR (X) (page 445). This produced a display on the VDU screen of the block of data which had just been typed in on the keyboard, and the operator could thus check for errors in the input before the data was 'fixed' into the memory store.

When all data from the study had been input, two further subroutine programs then calculated the Pearson r ('Z', subroutine Ref: Q (X, Y), page 446), and the linear regression equation constants a and b ('ZA', 'ZB', subroutine Ref: R (X, Y), page 447). A selection of these results are provided in Appendix IV: Table 35, pages 390 - 404.

The base program (Ref: JP VIS, pages 442-444) would perform this analysis on the mass of data for each of the N = 50 eyes individually. However, as Table 18 (page238) has indicated, it would be of interest to divide the eyes (i.e., the experimental data) into various groupings and thus assess the possible effects of, for example, sex, visual acuity level, or lens fitting. This facility was provided by the cueing of a further program (Ref: SUM, page 448/9). By typing in the filenames (i.e., the eyes) comprising the data-grouping required, this subroutine would abstract and sum the relevant data stored under each filename, over the five experimental factors, and generate a temporary holding file ('OVERAL') in the memory store. The cueing of a final program (Ref: JP LIST, page 450/1) then activated the on-line thermal printer to list

a hard copy of the values of the Pearson r and linear regression constants a and b under the several headings of the pairwise comparisons. As previously indicated (page 440), a selection of these results are provided in Appendix IV: Table 35, pages 390-404.

```
LIST

JP VIS

          DIMENSION TV(10,7),REAC(10,7),REFIX(10,7),ON(10,7),OFF(10,7)
          WRITE (1,5)
5         FORMAT(1H,'FILENAME = ')
          READ(1,6) FNAME
6         FORMAT(A6)
          WRITE(1,10)
10        FORMAT(1H,'TYPE(T) OR READ(R) DATA?')
S         CLA
S         KRB
S         CLA
S W1,     KSF
S         JMP      W1
S         KRB
S         TAD      (-322
S         SNA
S         JMP      W2
S         TAD      (-2
S         SZA
S         JMP      W1
S         CLA

          CONST=1.0
          CALL OOPEN('RXA1',FNAME)
          GOTO 25

S W2,     CLA
          CONST=-1.0
          CALL IOPEN('RXA1',FNAME)
          READ(4,20)((TV(I,J),I=1,10),J=1,7)
          READ(4,20)((REAC(I,J),I=1,10),J=1,7)
          READ(4,20)((REFIX(I,J),I=1,10),J=1,7)
          READ(4,20)((ON(I,J),I=1,10),J=1,7)
          READ(4,20)((OFF(I,J),I=1,10),J=1,7)
20        FORMAT(10F10.4)
          GOTO 90

25        WRITE(1,30)
30        FORMAT(1H,'TV SCORES')
          CALL RECOR(TV)
          WRITE(1,40)
40        FORMAT(1H,'REACTION TIMES')
          CALL RECOR(REAC)
          WRITE(1,50)
50        FORMAT(1H,'BLINK REFIX')
          CALL RECOR(REFIX)
          WRITE (1,60)
60        FORMAT(1H,'BLINK ON')
          CALL RECOR(ON)
          WRITE(1,70)
70        FORMAT(1H,'BLINK OFF')
          CALL RECOR(OFF)
```

```
 80       CALL OCLOSE

 90       WRITE(3,100)
100       FORMAT(1H,'TV SCORE/REACTION')
          CALL Q(TV,REAC)
          CALL R(TV,REAC)
          WRITE(3,110)
110       FORMAT (1H,'TV SCORE/REFIX')
          CALL Q(TV,REFIX)
          CALL R(TV,REFIX)
          WRITE(3,120)
120       FORMAT(1H,'TV SCORE/ON')
          CALL Q(TV,ON)
          CALL R(TV,ON)
          WRITE(3,130)
130       FORMAT (1H,'TV SCORE/OFF')
          CALL Q(TV,OFF)
          CALL R(TV,OFF)

          WRITE(3,200)
200       FORMAT(1H,'REACTION TIMES/TV')
          CALL Q(REAC,TV)
          CALL R(REAC,TV)

          WRITE(3,210)
210       FORMAT(1H,'REACTION TIMES/REFIX')
          CALL Q(REAC,REFIX)
          CALL R(REAC,REFIX)

          WRITE(3,220)
220       FORMAT(1H,'REACTION TIMES/ON')
          CALL Q(REAC,ON)
          CALL R(REAC,ON)

          WRITE(3,230)
230       FORMAT(1H,'REACTION TIMES/OFF')
          CALL Q(REAC,OFF)
          CALL R(REAC,OFF)

          WRITE(3,300)
300       FORMAT(1H,'BLINK REFIX/TV')
          CALL Q(REFIX,TV)
          CALL R(REFIX,TV)

          WRITE(3,310)
310       FORMAT(1H,'BLINK REFIX/REACTION')
          CALL Q(REFIX,REAC)
          CALL R(REFIX,REAC)

          WRITE(3,320)
320       FORMAT(1H,'BLINK REFIX/ON')
          CALL Q(REFIX,ON)
          CALL R(REFIX,ON)

          WRITE(3,330)
330       FORMAT(1H,'BLINK REFIX/OFF')
          CALL Q(REFIX,OFF)
          CALL R(REFIX,OFF)
```

```
      WRITE(3,400)
400   FORMAT(1H,'BLINK ON/TV')
      CALL Q(ON,TV)
      CALL R(ON,TV)

      WRITE(3,410)
410   FORMAT(1H,'BLINK ON/REACTION')
      CALL Q(ON,REAC)
      CALL R(ON,REAC)

      WRITE(3,420)
420   FORMAT(1H,'BLINK ON/REFIX')
      CALL Q(ON,REFIX)
      CALL R(ON,REFIX)

      WRITE(3,430)
430   FORMAT(1H,'BLINK ON/OFF')
      CALL Q(ON,OFF)
      CALL R(ON,OFF)

      WRITE(3,500)
500   FORMAT(1H,'BLINK OFF/TV')
      CALL Q(OFF,TV)
      CALL R(OFF,TV)

      WRITE(3,510)
510   FORMAT(1H,'BLINK OFF/REACTION')
      CALL Q(OFF,REAC)
      CALL R(OFF,REAC)

      WRITE(3,520)
520   FORMAT(1H,'BLINK OFF/REFIX')
      CALL Q(OFF,REFIX)
      CALL R(OFF,REFIX)

      WRITE(3,530)
530   FORMAT (1H,'BLINK OFF/ON')
      CALL Q(OFF,ON)
      CALL R(OFF,ON)

      CALL EXIT
      END
```

```
LIST

          SUBROUTINE RECOR(X)
          DIMENSION X(10,7)
          DO 100 J=1,7
S P2,     CLA
          K =J-1
          WRITE(1,5)K
5         FORMAT(1H,'VISIT = ',I1)
10        DO 50 I=1,10
          READ(1,20) X(I,J)
20        FORMAT(F10.4)
50        CONTINUE
          WRITE(1,60)
60        FORMAT (1H,'OK?')
S         KRB
S         CLA
S P1,     KSF
S         JMP       P1
S         KRB
S         TAD       (-215
S         SZA
S         JMP       P2
S         CLA
          WRITE(4,70)(X(I,J),I=1,10)
70        FORMAT(10F10.4)
100       CONTINUE
          RETURN
          END
```

LIST

```
      SUBROUTINE Q(X,Y)
      DIMENSION X(10,7),Y(10,7),Z(7)
      DO 100 I=1,7
      AVX=0.0
      AVY=0.0
      DO 10 J=1,10
      AVX=AVX+X(J,I)
10    AVY=AVY+Y(J,I)
      AVX=AVX/10.0
      AVY=AVY/10.0
      CROSS=0.0
      XVAR=0.0
      YVAR=0.0
      DO 20 J=1,10
      CROSS=CROSS+(X(J,I)-AVX)*(Y(J,I)-AVY)
      XVAR=XVAR+(X(J,I)-AVX)**2
20    YVAR=YVAR+(Y(J,I)-AVY)**2
      Z(I)=CROSS/SQRT(XVAR*YVAR)
100   CONTINUE
      WRITE (3,110)(Z(I),I=1,7)
110   FORMAT (1H ,30X,7F12.4)
      RETURN
      END
```

```
LIST

      SUBROUTINE R(X,Y)
      DIMENSION X(10,7),Y(10,7),ZA(7),ZB(7)
      DO 100 I=1,7
      SUMX=0.0
      SUMY=0.0
      SUMXY=0.0
      SUMX2=0.0
      DO 10 J=1,10
      SUMX=SUMX+X(J,I)
      SUMY=SUMY+Y(J,I)
      SUMXY=SUMXY+X(J,I)*Y(J,I)
10    SUMX2=SUMX2+X(J,I)**2
      ZB(I)=(SUMXY-SUMX*SUMY/10.0)/(SUMX2-(SUMX**2)/10.0)
      XBAR=SUMX/10.0
      YBAR=SUMY/10.0
      ZA(I)=YBAR-ZB(I)*XBAR
100   CONTINUE
      WRITE (3,110)(ZA(I),I=1,7)
110   FORMAT (1H,30X,7F12.4)
      WRITE (3,110)(ZB(I), I=1,7)
      RETURN
      END
```

```
LIST
SUM
          DIMENSION TV(10,7),REAC(10,7),REFIX(10,7),ON(10,7),OFF(10,7)
          DIMENSION SP(10,7),SQ(10,7),SR(10,7),ST(10,7),SV(10,7)
          DO 3 J=1,7
          DO 3 I=1,10
          SP (I,J)=0.0
          SQ (I,J)=0.0
          SR (I,J)=0.0
          ST (I,J)=0.0
          SV (I,J)=0.0
3         CONTINUE
5         WRITE(1,10)
10        FORMAT(1H,'READ(R) DATA FILE  OR STOP(S) ?')
S         CLA
S         KRB
S         CLA
S W1,     KSF
S         JMP       W1
S         KRB
S         TAD       (-322
S         SNA
S         JMP       W2
S         TAD       (-1
S         SZA
S         JMP       W1
S         CLA

          GOTO 500
S W2,     CLA
          WRITE(1,20)
20        FORMAT(1H,'FILENAME  = ')
          READ(1,30) FNAME
30        FORMAT (A6)
          CALL IOPEN('RXA1', FNAME)
          READ(4,40)((TV(I,J),I=1,10),J=1,7)
          READ(4,40)((REAC(I,J),I=1,10),J=1,7)
          READ(4,40)((REFIX(I,J),I=1,10),J=1,7)
          READ(4,40)((ON(I,J),I=1,10),J=1,7)
          READ(4,40)((OFF(I,J),I=1,10),J=1,7)
40        FORMAT (10F10.4)

          DO 50 J=1,7
          DO 50 I=1,10
          SP(I,J)=SP(I,J)+TV(I,J)
          SQ(I,J)=SQ(I,J)+REAC(I,J)
          SR(I,J)=SR(I,J)+REFIX(I,J)
          ST(I,J)=ST(I,J)+ON(I,J)
          SV(I,J)=SV(I,J)+OFF(I,J)
50        CONTINUE
          GOTO 5
```

```
500       CALL OOPEN('RXA1','OVERAL')
          WRITE(4,110)((SP(I,J),I=1,10),J=1,7)
          WRITE(4,110)((SQ(I,J),I=1,10),J=1,7)
          WRITE(4,110)((SR(I,J),I=1,10),J=1,7)
          WRITE(4,110)((ST(I,J),I=1,10),J=1,7)
          WRITE(4,110,((SV(I,J),I=1,10),J=1,7)
110       FORMAT(10F10.4)
          CALL OCLOSE
          CALL EXIT
          END
```

```
LIST
JPLIST
          DIMENSION TV(10,7),REAC(10,7),REFIX(10,7),ON(10,7),OFF(10,7)
          WRITE(1,10)
10        FORMAT (1H,'FILENAME = ')
          READ(1,20) FNAME
20        FORMAT(A6)
          CALL IOPEN('RXA1',FNAME)
          READ(4,30)((TV(I,J),I=1,10),J=1,7)
          READ(4,30)((REAC(I,J),I=1,10),J=1,7)
          READ(4,30)((REFIX(I,J),I=1,10),J=1,7)
          READ(4,30)((ON(I,J),I=1,10),J=1,7)
          READ(4,30)((OFF(I,J),I=1,10),J=1,7)
30        FORMAT(10F10.4)
          WRITE(1,40)
40        FORMAT(1H,'SELECT DATA FILE BY NUMBER')
          WRITE(1,50)
50        FORMAT(1H,'1 = TV SCORES')
          WRITE(1,60)
60        FORMAT(1H,'2 = REACTION TIMES')
          WRITE(1,70)
70        FORMAT(1H,'3 = BLINK REFIX')
          WRITE(1,80)
80        FORMAT(1H,'4 = BLINK ON')
          WRITE(1,90)
90        FORMAT(1H,'5 = BLINK OFF')
S         CLA
S         KRB
S         CLA
S WO,     KSF
S         JMP      WO
S         KRB
S         TAD      (-261
S         SNA
S         JMP      W1
S         TAD      (-1
S         SNA
S         JMP      W2
S         TAD      (-1
S         SNA
S         JMP      W3
S         TAD      (-1
S         SNA
S         JMP      W4
S         TAD      (-1
S         SNA
S         JMP      W5
S         JMP      WO
```

```
S W1,    CLA
         WRITE(3,100)((TV(I,J),I=1,10),J=1,7)
         CALL EXIT
S W2,    CLA
         WRITE(3,100)((REAC(I,J),I=1,10),J=1,7)
         CALL EXIT
S W3,    CLA
         WRITE(3,100)((REFIX(I,J),I=1,10),J=1,7)
         CALL EXIT
S W4,    CLA
         WRITE(3,100)((ON(I,J),I=1,10),J=1,7)
         CALL EXIT
S W5,    CLA
         WRITE(3,100)((OFF(I,J),I=1,10),J=1,7)
100      FORMAT (1H, 10F10.4)
         CALL EXIT
         END
```

APPENDIX VII

Statistical Procedures

Some notes are appended in connection with certain of the statistical procedures utilised in the work reported herein. The basic principles of the tests are discussed, and references to examples illustrating the computational stages (utilising experimental data as tabulated in Appendices I - IV) are provided. Statistical tables referred to included: Pearson and Hartley (1966), Rohlf and Sokal (1969), Fisher (1970), Fisher and Yates (1974), Snedecor and Cochran (1980).

APPENDIX VIIA

Analysis of Variance and Student t-ratio

Analysis of variance (ANOVA) is a parametric statistical procedure for comparing the differences between two or more samples simultaneously within a single test. It is the ratio between the variance ($\hat{S}_s^2$) of a given sample and an estimate of the error variance (the random or residual variation, $\hat{S}p^2$) for the total population. This ratio, the F-ratio, is defined:

$$F = \hat{S}_s^2 \ / \ \hat{S}_p^2$$

The sampling distribution of F varies as a function of sample size; consequently, the degrees of freedom (df) must be taken into account. Since F is based upon two estimates of variance, each based upon a different number of cases, the sample distribution of F is tabled in terms of the df associated with both the numerator and the denominator of the ratio. Tests of the significance of the F-ratio may be made subsequently by reference to the standard published ANOVA tables.

Conventionally, a value of F equal to or just greater than the tabulated value for p (the probability that the ratio would have occurred by chance) at 0.05 level suggests that the null hypothesis, H_o, should be rejected. Where F is equal to or greater than p at 0.01 level, H_o may be definitely rejected.

It should be noted that in the two-sample case, the F - ratio yields probability values identical to those of the Student t-ratio. This latter is a test statistic for determining the significance of a difference between means (two-sample case) or for testing the hypothesis that a given sample mean was drawn from a population with the mean specified under the null hypothesis (one-sample case). It is employed when the population standard deviation is not known. A worked example illustrating the computational stages of a Student t-ratio is provided in Appendix II: Table 24, pages 282-283.

APPENDIX VIIB

Tukey's Method for the Multiple Comparison of Means

In the event of the establishment of a significant F-ratio, the inevitable conclusion is that the sample means are not all estimates of a common population mean. Such a result permits the investigation of specific hypotheses. (In the absence of a significant F-ratio, any significant differences between specific comparisons would have to be regarded as suspicious, very possibly representing a chance difference.)

Several tests have been developed which permit the investigation of specific hypotheses concerning population parameters. A popular test is the a posteriori procedure which has been developed by Tukey (1953) for making pairwise comparisons among means when the overall F-ratio is significant. Tukey published his discussions of the problems of multiple comparisons in a privately circulated monograph (1953); Ryan (1959) has provided full details of Tukey's method, and Runyon and Haber (1980) provide a summary.

In essence, the method establishes that the difference between two means is significant, at a given probability level, if it equals or exceeds the WSD ('wholly significant difference' : Tukey 1953), which is:

$$WSD = SR \times S = SR \times \sqrt{\hat{S}_w^2 / a},$$

where $\hat{S}_w^2$ = the within-group variance estimate (mean square for error)

a = the number of cases upon which each mean is based.

SR = Percentage point of the studentised range as read from the table (at p = 0.01 or 0.05) for V df and n number of means.

A worked example illustrating this procedure is provided in Appendix I:

Table 21A, pages 268-270.

APPENDIX VIIC

Linear Regression Analysis and the Correlation Coefficient

In order to express quantitatively the extent to which two variables are related, it is necessary to calculate a correlation coefficient. For use with interval or ratio-scaled variables, the Pearson product-moment correlation coefficient (r) should be employed. The Pearson r represents the extent to which the same individuals or events occupy the same relative position on two variables, X and Y. For any bivariate distribution, the value of r will lie between + 1.00 and -1.00. For r = + 1.00, X and Y are directly or positively correlated; for r = -1.00, X and Y are inversely or negatively correlated.

However, it should be remembered that the Pearson r reflects only the linear relationship between two variables. Failure to find evidence of a relationship may be due to one of several possibilities:

(i) The variables are, in fact, unrelated.

(ii) The variables are related in a non-linear fashion.

(iii) The range of values of one of the variables is too restricted (truncated range).

The assumption of linearity of relationship is the most important requirement to justify the use of the Pearson r as a measure of relationship between two variables. It is not necessary that r be calculated only with normally distributed variables. So long as the distributions are unimodal and relatively symmetrical (as revealed by a scatter diagram), a Pearson r may legitimately be computed.

Tables exist whereby the level of significance (on the basis of a t-test) of the correlation coefficient may be established. The value of r is tested with (N - 2) df: the H_o is that the variables are uncorrelated.

Correlational analysis facilitates predictions from one variable to another. The general algebraic formula for a straight line will be remembered:

$$Y = a + bX$$

where X and Y represent variables that change from individual to individual, and a and b represent constants for a particular set of data. More specifically, b represents the slope of a line relating values of Y to values of X, i.e., the regression of Y on X.

The above formula may be used to predict Y from known values of X. When the correlation is precisely $\pm$ 1.00, the predictions are perfect. However, obtained correlations are very rarely perfect, so the 'best-fit' straight line is employed. This is the regression line and is defined as that straight line which makes the squared deviations around it minimal. The standard deviation around the regression line is termed the standard error of estimate.

For an example of the linear regression/correlation procedure, refer to Appendix V, (pages 426-430) and Appendix VIB; computer program, Ref: JP2 (pages 435-438). Reference should also be made to Pointer et al. (1980b, 1981).

APPENDIX VIID

The Point Biserial Coefficient Analysis

It is not unusual to encounter bivariate instances where one variable is dichotomous (i.e., the observations can take only one of two possible values, e.g., true/false, male/female) and the other variable is continuous (i.e., the observations can take any one of a number of different values). The special correlation coefficient which is suited to such cases is referred to as the point biserial coefficient.

The computational procedures in the determination of the coefficient are described by Edwards (1976); tabulated values of the t-ratio can be used to establish the level of significance of the coefficient. A worked example illustrating this procedure is provided in Appendix IV: Table 37A(II), pages 408-409.

APPENDIX VIII

The Rationale of the Electronic Circuitry Controlling the Presentation of the TV Stimuli and the Registering of Subjective Responses

(Written in conjunction with Mr W C Peaston)

The angular broken ring TV stimulus may be considered to be generated in a five by five matrix of cells, only four of which change for the four orientations (refer to annotated Figure 29, page 461). If one considers an elemental matrix, where each row of cells is produced by one line scan and the five successive rows are five successive lines of the scan raster, then the five cells in each row correspond to five cycles of a clock oscillator. The frequency of the latter is such that one cycle corresponds to the horizontal distance which is equal to the vertical line separation distance. The frequency of this oscillator is derived as follows:-

Number of lines in one field scan = 300.

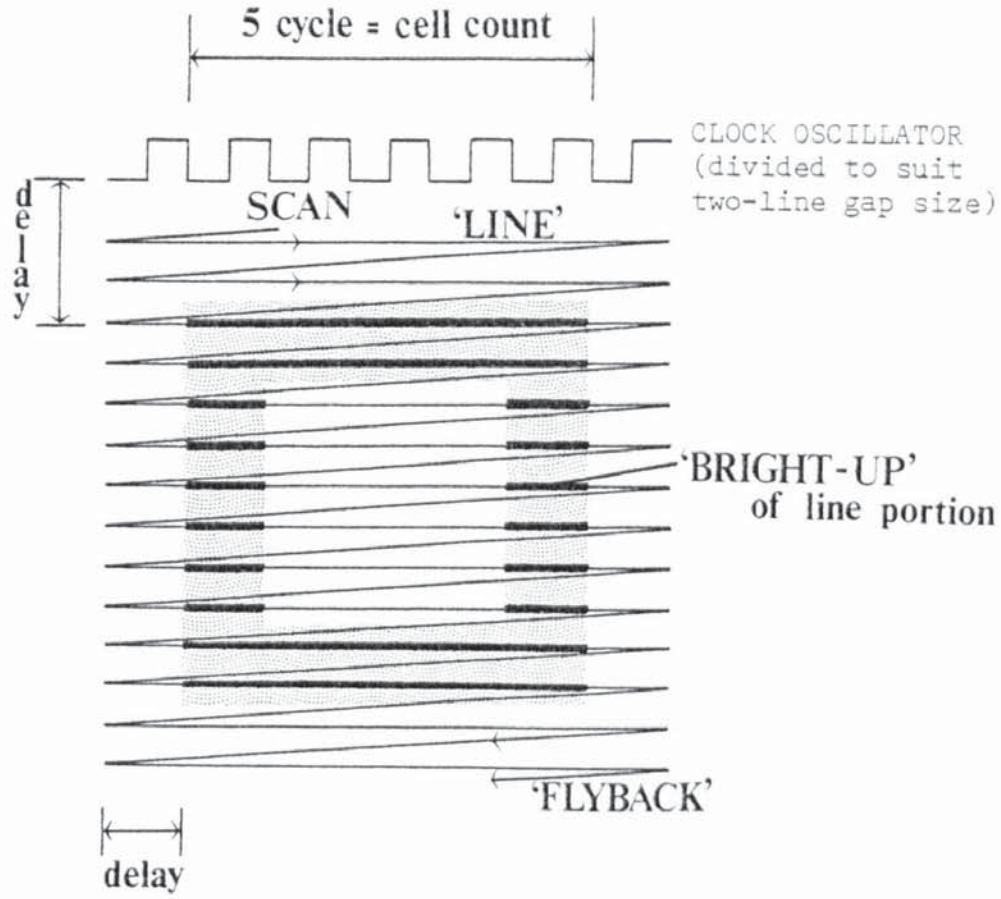
Aspect ratio of TV viewing screen = 4 X 3,

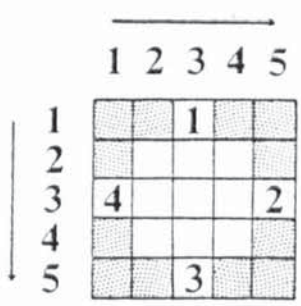
i.e., one line is equivalent to 400 line spacings.

One line takes 64 μs to scan; therefore required frequency = $1/\frac{64}{400}$ = 6.25 MHz. (In fact, since the smallest cell is of two line size - as discussed in Section 4.3Aii, pages 90-96 - the actual clock frequency is 3.125 MHz).

Figure 29 (annotated) : The generation of the square 5 x 5 'cell' matrix (at the 'two-line' size)

FIG. 29





cell positions
established by counting
divided clock

4 POSSIBLE POSITIONS OF THE GAP
IN THE STANDARD SQUARE TO PRODUCE
THE BROKEN RING STIMULUS
(encoded to 2-bit binary code)

cell positions
established by counting
suitably divided line frequency

Line segment switching signals are derived by combining the outputs of the row and column counters (count of five to binary code, in 3 bits) in a combinational logic matrix, the gap position being defined by the orientation code (2 bits).

The example of the square shown above is for a light-on-dark stimulus; for a dark-on-light stimulus the complete line is 'brightened-up' except for the segments of the cells - this merely involves inversion of the TTL (logic) signal before the Video Drive Output (refer to Figure 30, page 465).

If the five cycles of the clock corresponding to the square are counted in a chain of (3) binary counters, the 3-bit binary output of the chain gives a unique combination for each cell position in the series of five cycles. If this is repeated for the five successive lines which constitute the rows of the matrix, then the two 3-bit codes may be combined to uniquely define any cell in the matrix. This combination is performed in a network of logic gates, and further combined with the 2-bit code which defines which cell should represent the gap position. The result is a signal which may be used to switch the brightness level on these lines and produce a picture, i.e., the broken ring stimulus.

For a stimulus twice as large as the elemental one, the fundamental clock frequency is divided by a bistable circuit such that a half-frequency oscillation is available; this is applied to the five-count (vertical) circuit. Similarly the line frequency is divided by two and applied to the five-count (horizontal) circuit, two lines being thus switched to the same pattern at a time, this occurring five times. For other sizes of stimulus (lower) frequencies from further down the division chain are selected and applied to the counters.

In order that the stimulus appears in the approximate centre of the TV viewing screen the counting circuits must be delayed by an amount equivalent to the distance from the start of the line to the leading edge of the stimulus itself (approximately 30 μs for the smallest stimulus). This delay is different for each size of stimulus and must be selected by the size code to suit each stimulus to be presented.

A delay is of course required in both vertical and horizontal directions (Figure 29, page 461), the vertical delay operating only once per frame whereas the horizontal delay operates on every line used in the stimulus picture. To place the stimulus other than at the centre of the TV screen, a similar system of delays is employed, but then there are three possible delays in each direction for any size, and these are selected by a further position code. (This latter was, in fact, the preferred mode of operation as described in Section 4.3Aiv, page 97).

The codes, i.e., series of bits, for the size and orientation definition are generated by running high frequency oscillators into binary counting circuits and gating these with very low frequency timing signals. These timing signals are asynchronous to the oscillators, it thereby being assumed that over a run comprising N stimuli each code has a statistically equal chance of appearing at the outputs when the counters are stopped. This is in fact not so and the size code is actually generated in a fixed mixed size series (eight different sizes, the smallest two being repeated, producing a cycle of ten stimuli) to ensure a useful and repeatable process (notably in connection with a psychophysical test procedure).

The response system consists of four push buttons which each correspond to one orientation. An encoding circuit produces from a (latched) response the corresponding 2-bit code, and this is compared with the orientation code for the stimulus; if they are the same a 'correct' signal is generated. The stimulus and the response orientations are displayed together on LEDs in a facsimile of the stimulus on the front of the system's control panel, this aiding visual comparison.

The 'performance' indicator on the control panel is a straightforward counting and display circuit which may be switched to count the number of correct responses during a run or session, or to count the 1 ms pulses generated by a standard oscillator during the period between the appearance of the stimulus on the screen and the (correct) response of the subject; either may be used as performance indicators.

In Figure 30 (page 465) a schematic block diagram of the TV system's control circuitry (stimulus and response) is presented.

Figure 30: Block diagram of the TV system's control circuitry (stimulus and response modes).

FIG. 30

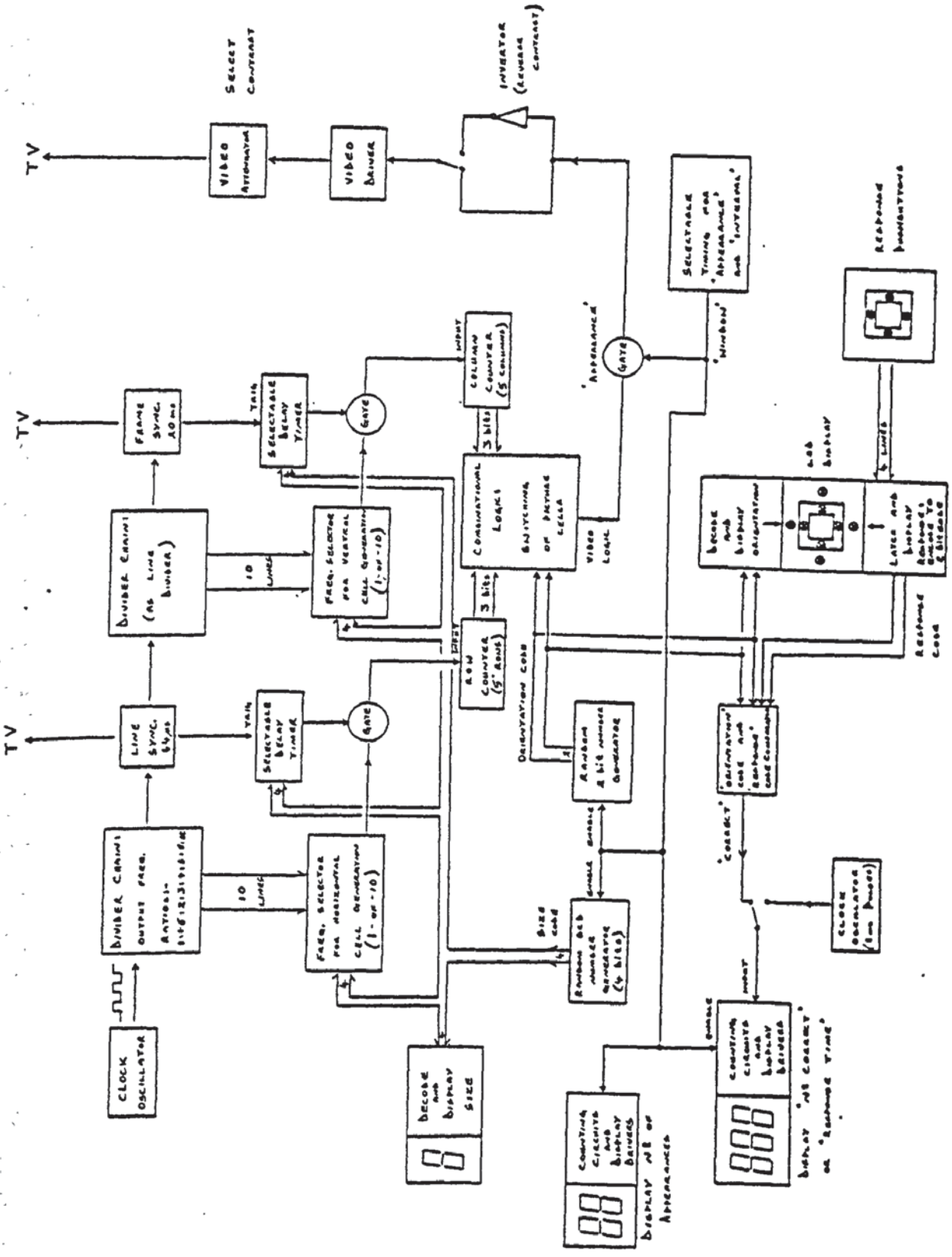
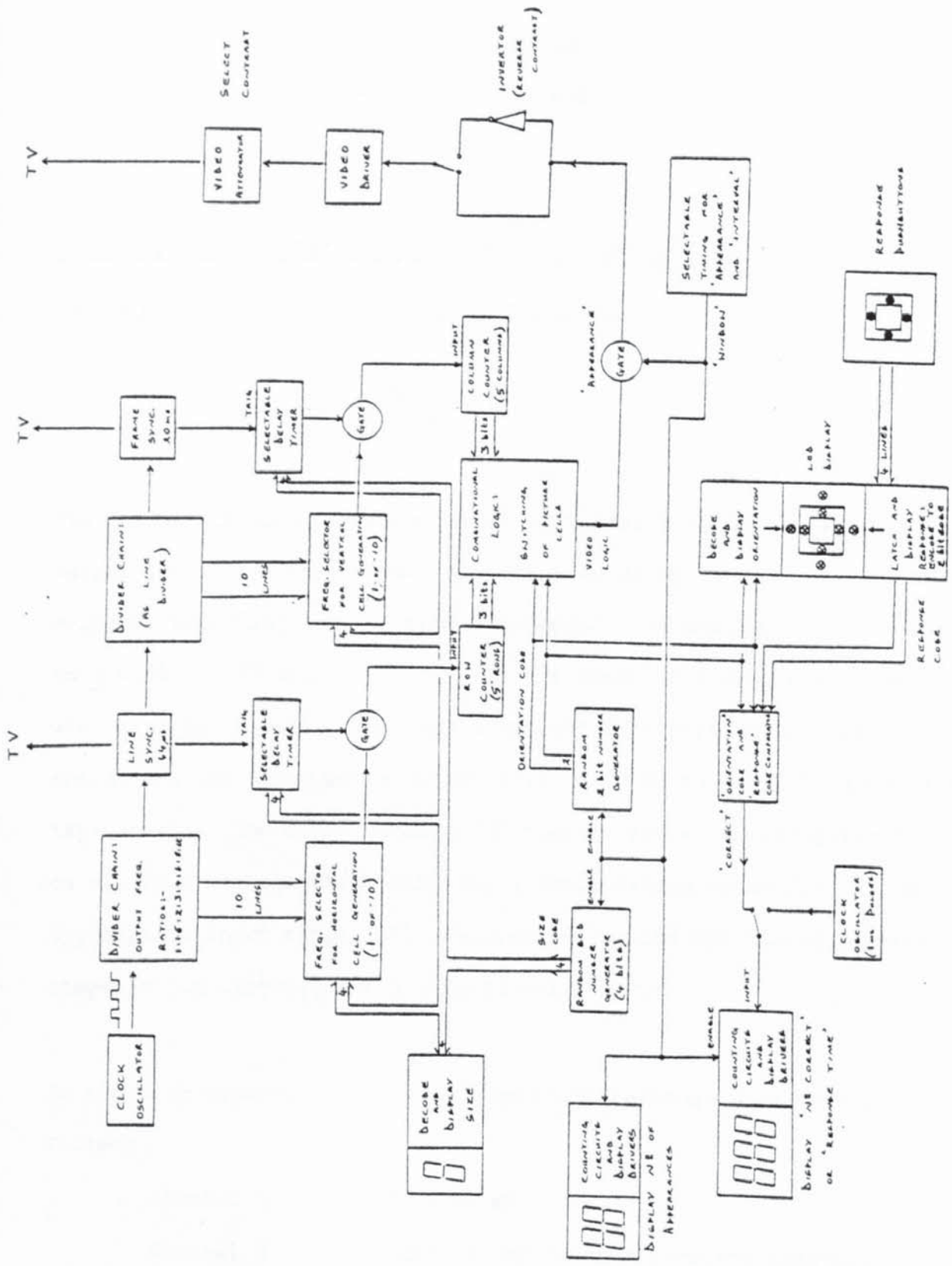

TV
VIDEO ATTENUATOR
VIDEO DRIVER
SELECT CONTRAST
INVERTOR (REVERSE CONTRAST)
FRAME SYNC. 40 ms
SELECTABLE DELAY TIMER
GATE
COLUMN COUNTER (5 COLUMNS)
3 bits
COMBINATIONAL LOGIC SWITCHING OF PAYOFF CELLS
'APPEARANCE'
SELECTABLE TIMING FOR 'APPEARANCE' AND 'INTERVAL'
'WINDOW'
RESPONSE INDICATIONS
DIVIDER CHAIN (AS LINE DIVIDER)
10 LINES
FREQ. SELECTOR FOR VERTICAL CELL GENERATION (1- OF -10)
ROW COUNTER (5 ROWS)
VIDEO LOGIC
DECODE AND DISPLAY ORIENTATION
LATCH AND DISPLAY RESPONSE CODE TO 5 BITS/ROW
5 LINES
RESPONSE CODE
LINE SYNC. 64 μs
ORIENTATION CODE
RANDOM 4 bit NUMBER GENERATOR
'CORRECT'
DIVIDER CHAIN OUTPUT FREQ. ANTILOG: 1:2:3:5:8:13:21:34:55:89
FREQ. SELECTOR FOR HORIZONTAL CELL GENERATION (1- OF -10)
SIZE CODE
RANDOM DOT NUMBER GENERATOR (4 bits)
CLOCK OSCILLATOR
CLOCK OSCILLATOR (1 ms PERIOD)
DECODE AND DISPLAY SIZE
COUNTING CIRCUITS AND DISPLAY DRIVERS
DISPLAY NO OF APPEARANCES
DISPLAY 'NO CORRECT' OR 'RESPONSE TIME'

FIG. 30


TV
VIDEO ATTENUATOR
SELECT CONTRAST
VIDEO DRIVER
INVERTOR (REVERSE CONTRAST)
SELECTABLE TIMING FOR 'APPEARANCE' AND 'INTERVAL'
'WINDOW'
'APPEARANCE'
GATE
RESPONSE PUSHBUTTONS
FRAME SYNC. 20 ms
TAU
SELECTABLE DELAY TIMER
INPUT
COLUMN COUNTER (5 COLUMNS)
3 bits
COMBINATIONAL LOGIC
DISTINCTION OF PICTURE CELLS
VIDEO LOGIC
LOG DISPLAY
DECODE AND DISPLAY ORIENTATION
LATCH AND DISPLAY RESPONSE (DELAYED TO 2 FIELDS)
4 LINES
RESPONSE CODE
DIVIDER CHAIN (AS LINE DIVIDER)
10 LINES
FREQ. SELECTOR FOR VERTICAL CELL GENERATION (1 OF 10)
ROW COUNTER (5 ROWS)
ORIENTATION CODE
RANDOM 2 BIT NUMBER GENERATOR
'ORIENTATION' CODE AND 'RESPONSE' CODE COMPARATOR
'CORRECT'
LINE SYNC. 64 μs
DIVIDER CHAIN OUTPUT FREQ. RATIOS: 1:16:2:3:4:5:6:7:8
FREQ. SELECTOR FOR HORIZONTAL CELL GENERATION (1 OF 10)
ENABLE
SIZE CODE
RANDOM BCD NUMBER GENERATOR (4 bits)
CLOCK OSCILLATOR
CLOCK OSCILLATOR (1 ms Pulses)
DECODE AND DISPLAY SIZE
COUNTING CIRCUITS AND DISPLAY DRIVERS
DISPLAY NR OF APPEARANCES
DISPLAY NR CORRECT OR 'RESPONSE TIME'

APPENDIX IX

Brief Details of the Data Recording Equipment

STUDY NO. 4

(vide Figure 23, page 211)

Tandberg Instrumentation Tape Recorder : Series 100

Manufacturer: Tandbergs Radiofabrikk A/S,
P. O. Box 9,
Korsvoll,
Oslo 8,
Norway.

The Series 100 model (now superseded by Series 115; 1976) is a light-weight portable four channel tape recorder using 0.63 cm (1/4 inch) magnetic recording tape. Three tape speeds are available, all accurate to $\pm$ 0.2% : 4.75 cms^{-1} ($1\frac{7}{8}$ ips) was the speed utilised in all the work reported herein. The tape transport incorporates capstan servo-drive, and can accommodate either 17.8 cm (7 inch) or 12.7 cm (5 inch) tape reels. The front located CRT monitor shows carrier deviation on all four channels simultaneously, facilitating selection of the appropriate input range. The flutter is low and additional flutter compensation improves the signal-to-noise ratio.

In the work reported herein, data recording arrangements were as follows:

Channel 1 - TV stimulus on

Channel 2 - TV stimulus off (whence response latency)

Channel 3 - Eye-blink activity

Channel 4 - (Non-operative)

TDK 'Audua' Recording Tape

Manufacturer: TDK Electronics Company Limited ,
Tokyo 103,
Japan.

TDK Tape Distribution (U.K.) Ltd.,
11th Floor: Pembroke House,
44 Wellesley Road,
Croydon,
Surrey, CRO 9XW.

Professional studio quality (high-output low-noise) sound recording tape. Model 'Audua' L-1800 (555m) polyester-based tapes were used (total tape thickness 34 μ), on 17.8 cm (7 inch) plastic open reels.

Lectromed (formerly Devices) Thermal Recorder : Models MX2/MX 212

Manufacturer: Lectromed Limited,
5 Le Chemin du Moulin St. Ouen,
Jersey,
Channel Islands.

Distribution and Service in mainland U.K.:

Ormed Engineering Ltd.,
32 Hyde Way,
Welwyn Garden City,
Hertfordshire, AL7 3AW.

Two channel high speed thermal pen recorders. Write-out is by hot stylus (with automatic heat control) on heat-sensitive paper ruled in two 50 mm channels (vide infra, page 468). Eight paper speeds are available : 2.5 mms^{-1} was the speed utilised in all the work reported herein. The paper drive mechanism is servo-controlled to an accuracy of $\pm$ 1% plus $\pm$ 0.008%$^{\circ}C^{-1}$ at all speeds and differential paper drive rollers ensure that paper wander is reduced to a negligible amount. A marker pen prints a time scale of seconds (pulses of 0.1s width), with minute markers (pulses of nominal 1.1s width), along the centre (Model MX2) or the edge (Model MX 212) of the chart paper : the basic clock accuracy is $\pm$ 0.5% plus $\pm$ 0.016%$^{\circ}C^{-1}$.

In the work reported herein, data printing arrangements were as follows:

Channel 1 - Response latency.

Channel 2 - Eye-blink activity record.

Lectromed Heat Sensitive Recording Paper (vide Figure 24, page 230).

Supplier in mainland U.K.: Ormed Engineering Ltd.,
32 Hyde Way,
Welwyn Garden City,
Hertfordshire, AL7 3AW.

A lightweight heat sensitive chart paper, Ref: S2250-14-2 (blue trace). Ruled in two channels of width 50 mm each, with 1mm squares overprinted every 5mm. The paper is supplied in 75m rolls, marked with the reference code and month and year of batch manufacture at intervals along one edge.

APPENDIX X

Miscellaneous Printed Forms and Data Tabulation Sheets

STUDY NO. 4

Figure 31: Example of advertisement posted to attract volunteer subjects for participation in the study.

Figure 32: Subject's appointment card. (Front and reverse side)

Figure 33: Example of subjective ranked criteria questionnaire sheet.

Figure 34: Example of totalling sheet - Tabulation of subject's reaction time data.

Figure 35: Example of totalling sheet - Tabulation of subject's eye-blink activity data.

Figure 36: Example of summary sheet - Tabulation of subject's TV score data.

Figure 37: Example of summary sheet - Tabulation of subject's reaction time data.

Figure 38: Example of summary sheet - Tabulation of subject's eye-blink activity data.

SUBJECTIVE RANKED CRITERIA

Carefully consider the following three aspects of soft contact lens wear. You are asked to indicate the word or phrase under each heading which you feel most closely describes your experience of soft contact lens performance to date.

STABILITY of Vision

	L ✓	R ✓
1. Whole of time		
2. Most of time		
3. Half of time		
4. Quarter of time		
5. Virtually none of time		

QUALITY of Vision

1. Excellent		
2. Good		
3. Just acceptable		
4. Poor		
5. Very poor		

COMFORT

1. Excellent - lens not felt		
2. Satisfactory		
3. Fair		
4. Poor		
5. Intolerable		

Do you have any additional comments or criticisms to make with regard to the general performance of your soft contact lenses?

REACTION TIME DATA

R 6/

Subject:

Visit:

App . . . . . B-on-W/ W-on-B

Inter . . . . . Contrast . . . .

STIM. Nº	1	2	3	$\bar{X} \pm$ S.D.
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				

L 6/

0				
1				
2				
3				
4				
5				
6				
7				
8				
9				

APPENDIX X : Figure 34.

BLINK DATA

STIMULUS Nº

Subject:

Visit:

App . . . B-on-W/ W-on-B

Inter . . . Contrast . . . .

R 1 6/

L 1 6/

SEQ.	STIMULUS... ON.. Nº	R	1/R	OFF.. Nº	R	1/R	(REFIX).. Nº	R	1/R
1									
10									
$\bar{X}$									

2

1									
10									
$\bar{X}$									

3

1									
10									
$\bar{X}$									

Mean

R

Mean

L

T.V. SCORE DATA

(Means, corrected for guessing)

Subject: Eye:

App . . . . . B-on-W/ W-on-B
Inter . . . . . Contrast . . . .

V.A. 6/	STIMULUS Nos 0	1	2	3	4	5	6	7	8	9
Specs.										
S/L 1										
2										
V 3										
I 4										
S 5										
I 6										
T										
#										

APPENDIX X : Figure 36.

REACTION TIME DATA

Subject: Eye:

App . . . . . B-on-W/ W-on-B
Inter . . . . . Contrast . . . .

V.A. %	STIMULUS No. 0	1	2	3	4	5	6	7	8	9
Specs.										
S/L 1										
VISIT 2										
VISIT 3										
VISIT 4										
VISIT 5										
VISIT 6										
VISIT #										

APPENDIX X : Figure 37.

BLINK DATA

Subject: Eye:

App . . . . . B-on-W/ W-on-B
Inter . . . . . Contrast . . . .

V.A. 6/	STIMULUS Nº									
	refix 0 on off	1	2	3	4	5	6	7	8	9
Specs.										
S/L 1										
VISIT # 2										
3										
4										
5										
6										

APPENDIX X : Figure 38.

APPENDIX XI

The Screening and Preparation of Volunteer Subjects

including a note upon

Soft Contact Lens Fitting

Examples of certain of the volunteer subject data recording and information sheets as used in the several research studies.

Figure 39: Confidential questionnaire sheet to be completed by volunteer subject:
Personal details and general medical/ophthalmic optical history.

Figure 40: Ophthalmic optical examination of volunteer subject.

Figure 41: Slit lamp biomicroscope examination of subject's cornea (following instillation of vital stains).

Figure 42: Declaration and consent form : Experimental subject.

Figure 43: Notes for guidance of volunteer subjects.

Figure 44: Example of information sheet issued to experimental subjects: STUDY NO. 4.

Figure 45: Example of supplementary information sheet issued to experimental subjects : STUDY NO. 4.

Figure 46: The fitting of soft contact lenses : example of lens fitting sheet and relevant notes.

THE UNIVERSITY OF ASTON IN BIRMINGHAM

DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

Questionnaire

CONFIDENTIAL Date: _____

Questionnaire to be completed in BLOCK LETTERS please.

Surname - Mr / Miss / Mrs _____ Other Names _____

Home Address _____ Term Address _____

_____ _____

_____ _____

_____ _____

Tel: _____ Tel: _____

Date of Birth _____ Occupation _____

Name of regular Optician (if any) Family Doctor

_____ _____

Practice Address _____ Surgery Address _____

_____ _____

_____ _____

Visual 'correction'

wearing at present: Spectacles ☐ Contact Lenses ☐ Both ☐ None ☐

If SPECTACLES worn: Age when spectacles first prescribed _____

Full Time ☐ Part Time ☐ All distances ☐ Distance Work ☐ Close Work ☐

If CONTACT LENSES worn: Every day ☐ Intermittently ☐ Infrequently ☐

Discontinued ☐

When was your last eye examination?

Have you any complaints regarding the performance of your present spectacle/contact lenses?

FAMILY HISTORY Are there any instances of eye diseases† in a .....

Parent ☐ Grandparent ☐

Brother/Sister ☐ None known ☐

†E.g.- • Glaucoma • Retinal Detachment • Cataracts • Blindness or very poor sight - unknown origin

P.T.O.

PERSONAL HISTORY

General Health:

- Good ☐
- Indifferent ☐
- Poor ☐

Any past:

- Eye Disease ☐
- Eye Injury ☐
- Neither ☐

Any eye treatment other than spectacles:

- Yes ☐
- No ☐

Please specify:

Do you suffer from any of the follows conditions:-

Frequent colds	☐	Red Eyes	☐
Catarrh	☐	Red eyelids	☐
Sinus trouble	☐	Scaly eyelashes	☐
Hay fever	☐	Styes	☐
Asthma	☐	Sore or gritty eyes	☐
Food Allergies	☐	Itching eyes	☐
Drug Allergies	☐	Watering eyes	☐
Boil, Abscesses	☐	Sticky eyes	☐
Pimples, Acne,	☐	Discharging eyes	☐
Lip Cold sores	☐	Intolerance to light	☐
Headaches/Migraine	☐	Double Vision	☐
Dandruff	☐	Intermittent "steamy" vision	☐

Are you at present taking any REGULAR pills, tablets, or medicines prescribed by your Doctor?

- Yes ☐
- No ☐
- Recently ☐

Please state what, if known:

OTHER RELEVANT COMMENTS:

Please Sign: _____

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DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

OPHTHALMIC OPTICAL EXAMINATION

CLINICAL RECORD Date: _____

Surname - Mr / Miss / Mrs _____ Other Names _____

Additional History and Symptoms:

VISION AND V/A:

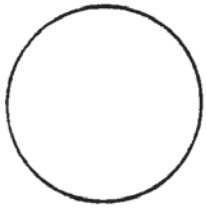
	Without Rx	Binoc	With Rx (if any)	Binoc
D	R		R	
	L		L	
N	R		R	
	L		L	

D.M.B. N.M.B.

OBJECTIVE EXAMINATION P.D. _____

Cover Test Conv. Reflexes Motility D/Eye

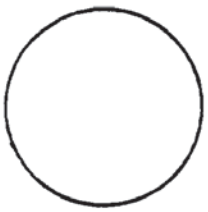
R External L



Cornea

Media

Fundus



REFRACTION R L

and Rx....

V/A R: L: Binoc:

O.M.B. Distance Near

Accm. R L ADD R & L Reads:

P.T.O.

(Figure 40)

KERATOMETRY

R _____ L _____

Instrument: _____

SLIT LAMP EXAMINATION

FACE

LIDS

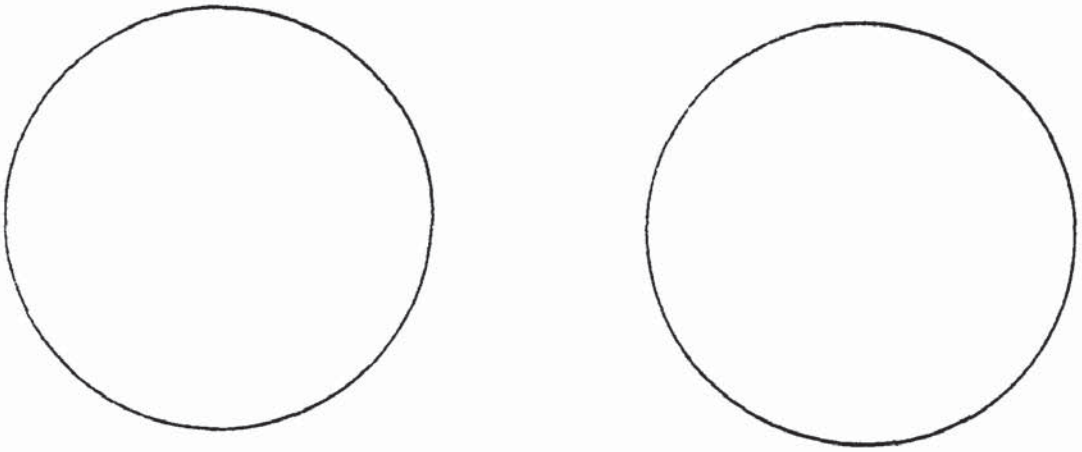
CONJ.
palp.
bulb.

CORNEA

IRIS

PUPIL

R L



RELEVANT COMMENTS:

Examined by: _____

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SOFT LENS RESEARCH

Slit Lamp Examination

(vital stains)

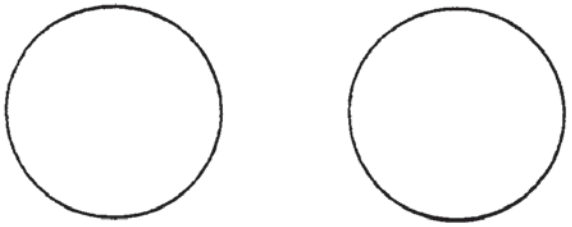
Patient - Mr / Miss / Mrs _____ Date _____

* Sodium Fluorescein (2%)

Evidence of staining and area: (Circle)

1. No staining
2. Diffuse
3. Punctate
4. Linear
5. Arcuate
6. Other ... specify

R L



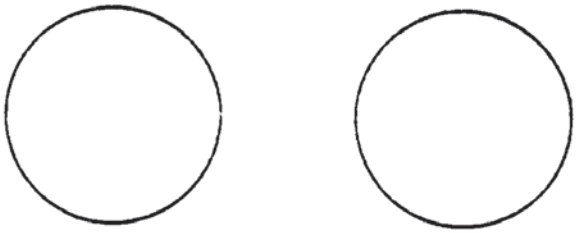
Depth: (Tick)

1. Epithelial
2. Involves stroma
3. Involves full corneal thickness

* Rose Bengal (1%)

Evidence of staining and area: (Circle)

1. No staining
2. Staining ... specify



Any Comments:

Examined by: _____

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DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

CONSENT FORM

DECLARATION to be signed by volunteer subjects on initial registration:

I have read the several sheets of notes for guidance and information of volunteer subjects attending the Soft Lens Research Clinic, and have received and read a written description of the experiment in which I am to take part.

I hereby agree to act as a volunteer experimental subject.

Signed _____

Date _____

Please complete in BLOCK LETTERS:

Name: _____

Address: _____

_____

_____

Witnesses - Registered Ophthalmic Optical Practitioners:

1. _____

2. _____

(Name) (Signature)

THE UNIVERSITY OF ASTON IN BIRMINGHAM

DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

NOTES FOR GUIDANCE OF VOLUNTEER SUBJECTS : PLEASE READ NOW AND RETAIN

In agreeing to participate in this research study you are necessarily exposing yourself to a greater degree of risk than a non-participant. Various measures have been taken to minimise any risk to your eyes, including careful experimental design and the use of only clinically-proven forms of soft contact lens and accepted fitting techniques. However, it is a feature of any research investigation that the final outcome to an extent is unknown.

The soft lenses which will be ethically prescribed for you are of a daily wear type widely available from Ophthalmic Opticians in both the UK and abroad, and are manufactured to British and International Standards by Hydron Europe Limited, Farnborough, Hampshire.

During the course of each experimental visit various safeguards will be adopted. If at any point in the procedure you feel in any discomfort or distress, you may ask for the experiment to be stopped : the investigator is under written instructions to observe your request. Furthermore at completion of the study and on several other prior occasions, the investigator (who is a Registered Ophthalmic Optician) will examine your eyes for any signs of an adverse response to soft contact lens wear, and you may be given some form of treatment or medication.

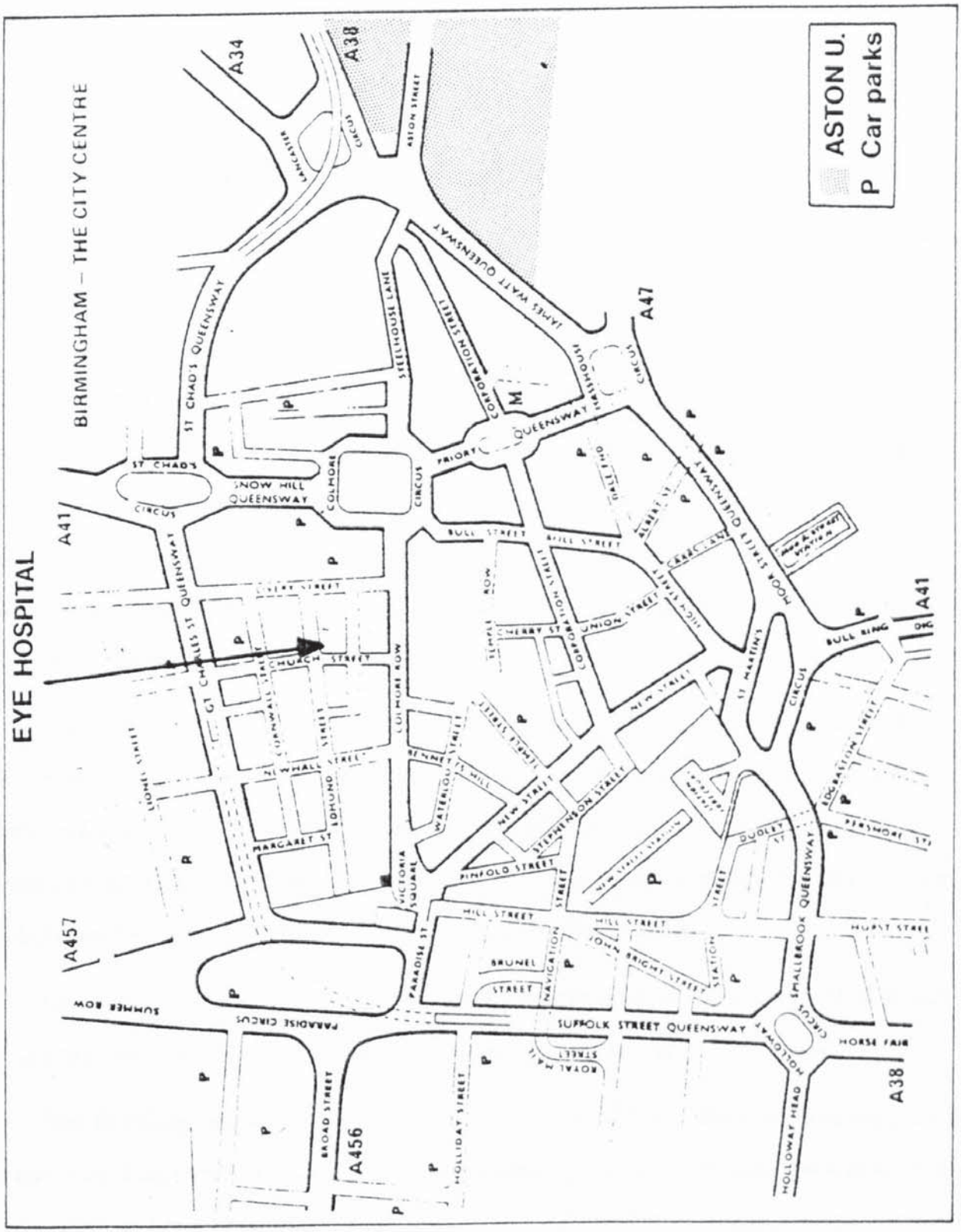
When you leave the research clinic, should you feel that there is any reasonable doubt regarding the health or comfort of your eyes, please do not hesitate to contact the investigator by telephone : the number is (021-) 359 5355. If problems arise in the evening or at the week-end, then please contact Dr J R LARKE at home on (021-) 449 0202. Both of these telephone numbers are on your appointment card, which you should keep in a safe place.

In the event of emergency, you should attend the Casualty Department, Birmingham and Midland Eye Hospital, Church Street : the city centre location of this facility is shown on the map attached to these notes. On arrival, you should clearly state that you are involved in a soft contact lens investigation, produce your University Research Clinic appointment card, and concisely describe your symptoms.

Jonathan S Pointer

Dr J R Larke

Location: Birmingham and Midland Eye Hospital,
Church Street,
Birmingham, B1.



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DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

- STUDY NO. 4 -

VISUAL PERFORMANCE WITH HYDROPHILIC CONTACT LENSES

Information for volunteer subjects: Please read now and retain.

Provided that no contra-indications arise from this initial ophthalmic optical examination, it is proposed that you will be fitted with daily wear hydrophilic ('soft') contact lenses. You will be charged a reduced fee of £60, half of which will be refunded only if you keep ALL of your appointments. The dates and times of these appointments will be confirmed with you prior to your receipt of the lenses and must be rigidly adhered to. Please note that the lenses are all manufactured from the usual commercial HYDRON^{R} material, and are of a type widely available in ophthalmic optical practice.

Prior to any fitting, various measurements and inspections will be made of your eyes using standard ophthalmic instruments. Routine examinations will also be made at each experimental session. Your vision will be checked at regular intervals with the conventional Optician's test chart, in addition to assessments made with a television system.

You will be asked to fill in a questionnaire and also to give subjective impressions of various aspects of the lens fit and performance.

The fitting procedure will involve the use of a number of lenses, and you may not find this a particularly pleasant process. Please remember that if you want a lens removed at any time this will be done immediately.

Jonathan S Pointer

Dr J R Larke

THE UNIVERSITY OF ASTON IN BIRMINGHAM

DEPARTMENT OF OPHTHALMIC OPTICS

SOFT LENS RESEARCH

- STUDY NO. 4 -

INSTRUCTION AND ADDITIONAL INFORMATION FOR VOLUNTEER SUBJECTS WEARING CONTACT LENSES

1. You should attend for all your appointments wearing your contact lenses.

   The lenses should have been on your eyes for at least one hour prior to your appointment time. Obviously, if your appointment is later in the day you should have been wearing the lenses for a considerably longer period of time.

2. Recommended MAXIMUM daily wearing times for this study:

DAY	WEEK 1	WEEK 2	WEEK 3	WEEK 4
1	6 hrs.			
2	7 hrs.			
3	8 hrs.			
4	9 hrs.	14 hrs.	16 hrs.	16 hrs.
5	10 hrs.			
6	11 hrs.			
7	12 hrs.			

   Please note that the maximum daily wearing time is 16 hours; on no account should these lenses be worn overnight.

3. Please apply the utmost attention to hygiene when handling your lenses.

4. You are strongly advised to insure your contact lenses. Appropriate cover may be obtained by the taking out of a specific contact lens insurance policy or, in some cases, by incorporation into existing House Contents insurance policies.

5. Contact Lens Aftercare

   Aftercare appointments are recommended at three months, six months, twelve months and thence annually. These can be undertaken in the Soft Lens Research Clinic (Room 188), Department of Ophthalmic Optics, University of Aston in Birmingham or, if you would prefer, by your own private Ophthalmic Optician (to whom lens details, etc., may be forwarded if requested). Please ensure that you have these regular check-ups.

Jonathan S Pointer

Dr J R Larke

Notes re. Figure 46 (page 491) : The Fitting of Soft Contact Lenses

(et vide Section 8.2, pages 222-226).

All soft contact lenses used in this work were pHEMA standard thickness daily wear lenses manufactured by Hydron Europe. They were all fitted by one person (the investigator) in strict adherence to the instructions contained in the Manufacturer's practitioner fitting manual (Anon 1978b).

The BCOR of an initial trial lens was selected on the basis of a fixed relationship, viz: K_f + 1.00 $\pm$ 0.25 mm. The lens diameter was 2mm larger than the visible iris diameter. After twenty minutes adaptation, the lens fit was judged on the basis three ranked fitting criteria, in conjunction with aspects of visual acuity and comfort.

For right and left eyes individually, following a series of normal unforced eye-blinks, assess:

* Objective factors

RANK	RIDING	LAG	REFLEX
1 (tight)	High	⟨ 1mm	Gross distortion
↑			
2 optimum	Central	1mm	No Fluctuation
↓			
3 (loose)	Low	⟩ 1mm	Spreading of Reflex

continued/...

LENS FITTING SHEET

Subject:

Date: Eye: R:

Lens Type:

Iris Dia. . . . . mm

'K' Reading $\frac{x}{x}$

Lens spec^{n}	Fitting criteria: riding	lag	reflex	Vision: v.a.	over-r$_x$; b.sph.: v.a.	stabil	quality D	N	Com-fort	Action
1				6/	6/					
2										
3										
4										

Best Fit:

BCOR. . . . . DIA. . . . .

jsp 1.79

Continued:

* Subjective factors

RANK	VISUAL STABILITY	VISUAL QUALITY	LENS COMFORT
1 (Optimum)	whole of time	excellent	excellent
2	most of time	good	satisfactory
3	half of time	just acceptable	fair
4	quarter of time	poor	poor
5	virtually none of time	very poor	intolerable

On the basis of these assessments, the lens fit could be modified, in order to arrive at an optimum soft contact lens fitting in the majority of cases. This fitting was specified by lens BCOR, overall (external) diameter and back vertex power.

APPENDIX XII

Subject Acceptance Profiles

APPENDIX XIIA

STUDY NO. 1 - A Suitable Subject:

1. Not younger than 18 nor older than 28 years of age.
2. Male or female, and of Caucasian extraction.
3. No previous history of eye injury or ophthalmological surgical operation.
4. Not currently receiving any form of ocular medication, nor within the last six months.
5. Not currently receiving any form of regular systemic medication (excluding oral contraceptives).
6. No orthoptic anomalies and has never undergone a course of orthoptic treatment.
7. No obvious ocular anomaly as indicated by ophthalmoscopy.
8. Good general health.
9. Not currently undergoing any psychiatric treatment.
10. Ametropic, but exhibiting myopia, with or without astigmatism, only (i.e., no hyperopia or presbyopia).
11. Spectacle refraction:

    spherical component, range $\overline{0}.50$ to $\overline{8}.00$ DS (inclusive).

    cylinder (if present), $\overline{2}.00$ DC maximum.
12. Binocular visual acuity with best spectacle correction within the range 6/3 to 6/7.5 on the internally illuminated Landolt chart at 6m (conforming to B.S. 4274: 1968).

Non-compliance with any of these features excluded the volunteer subject from participation in the study.

APPENDIX XIIB

STUDY No. 2 - A suitable subject:

1. Not younger than 18 nor older than 28 years of age.
2. Male or female, and of Caucasian extraction.
3. No previous history of eye injury or ophthalmological surgical operation.
4. Not currently receiving any form of ocular medication, nor within the last six months.
5. Not currently receiving any form of regular systemic medication (excluding oral contraceptives).
6. No orthoptic anomalies and has never undergone a course of orthoptic treatment.
7. No obvious ocular anomaly as indicated by ophthalmoscopy
8. Good general health.
9. Not currently undergoing any psychiatric treatment.
10. Ametropic, but exhibiting myopia, with or without astigmatism, only (i.e. no hyperopia or presbyopia).
11. Spectacle refraction:

    spherical component, range $\overline{0}.50$ to $\overline{8}.00$ DS (inclusive)

    cylinder (if present), $\overline{2}.00$ DC maximum
12. Monocular visual acuity with best spectacle correction before the dominant eye of at least 6/4 on the internally illuminated Landolt chart at 6m (conforming to B.S. 4274: 1968).

Non-compliance with any of these features excluded the volunteer subject from participation in the study.

APPENDIX XIIC

STUDY NO. 3 - A suitable subject:

1. Not younger than 18 nor older than 28 years of age.
2. Male or female, and of Caucasian extraction.
3. No previous history of eye injury or ophthalmological surgical operation.
4. Not currently receiving any form of ocular medication, nor within the last six months.
5. Not currently receiving any form of regular systemic medication (excluding oral contraceptives).
6. No orthoptic anomalies and has never undergone a course of orthoptic treatment.
7. Does not suffer from 'hay fever', asthma, allergic dermatitis or any other allergic conditions.
8. Not subject to recurrent or persistent conjunctival injection, photophobia, excessive lacrimation, scaly eyelids, recurrent styes or other lid infections, nor repeated colds.
9. No obvious lid anomaly nor abnormal lid/cornea relationship.
10. Visible iris diameter within the range 12.0 to 13.5 mm.
11. No obvious conjunctival or corneal anomaly (congenital or pathological) as indicated by slit lamp biomicroscope examination.
12. (a) No staining of the cornea with Fluorescein Sodium, B.P. (2%)
    (b) No unusual staining of the cornea/bulbar conjunctiva with Rose Bengal (1%).

13. No other obvious ocular anomaly as indicated by ophthalmoscopy.

14. No unusual corneal topography.

15. No previous experience of contact lens wear.

16. Good general health.

17. Not currently undergoing any psychiatric treatment.

18. Ametropic, but exhibiting myopia, with or without astigmatism, only (i.e., no hyperopia or presbyopia).

19. Spectacle refraction:

    spherical component, range $\overline{1}.25$ to $\overline{7}.50$ DS (inclusive)

    cylinder (if present), $\overline{1}.00$ DC maximum

20. Monocular visual acuity with best spectacle correction or optimally - fitting soft contact lens before the dominant eye of at least 6/4 on the internally illuminated Landolt chart at 6m (conforming to B.S. 4274: 1968).

21. Central corneal curvature (as measured by keratometer) within the range 7.250 to 8.350mm

22. Investigator able to fit an optimum soft contact lens (Hydron Europe pHEMA standard thickness daily wear variety) within the fitting relationship of $K_f + 1.00 \pm 0.25$ mm.

Non-compliance with any of these features excluded the volunteer subject from participation in the study.

==========

APPENDIX XIID

STUDY NO. 4 - A suitable subject:

1. Not younger than 18 nor older than 28 years of age.
2. Male or female, and of Caucasian extraction.
3. No previous history of eye injury or ophthalmological surgical operation.
4. Not currently receiving any form of ocular medication, nor within the last six months.
5. Not currently receiving any form of regular systemic medication (excluding oral contraceptives).
6. No orthoptic anomalies and has never undergone a course of orthoptic treatment.
7. Does not suffer from 'hay fever', asthma, allergic dermatitis or any other allergic conditions.
8. Not subject to recurrent or persistent conjunctival injection, photophobia, excessive lacrimation, scaly eyelids or other lid infections, nor repeated colds.
9. No obvious lid anomaly nor abnormal lid/cornea relationship.
10. Visible iris diameter within the range 12.0 to 13.5 mm.
11. No obvious conjunctival or corneal anomaly (congenital or pathological) as indicated by slit lamp biomicroscope examination.
12. (a) No staining of the cornea with Fluorescein Sodium, B.P. (2%)
    (b) No unusual staining of the cornea/bulbar conjunctiva with Rose Bengal (1%).

13. No other obvious ocular anomaly as indicated by ophthalmoscopy.

14. No unusual corneal topography.

15. No previous experience of contact lens wear.

16. Good general health.

17. Not currently undergoing any psychiatric treatment.

18. Ametropic, but exhibiting myopia, with or without astigmatism, only (i.e., no hyperopia or presbyopia).

19. Spectacle refraction:

    spherical component, range $\overline{1}.25$ to $\overline{7}.50$ DS (inclusive)

    cylinder (if present), $\overline{1}.00$ DC maximum

20. Monocular visual acuity with best spectacle correction of at least 6/4, or with optimally - fitting soft contact lens of at least 6/4 (several attempts permissible), on the internally illuminated Landolt chart at 6m (conforming to B.S. 4274: 1968).

21. Central corneal curvature (as measured by keratometer) within the range 7.250 to 8.350 mm.

22. Investigator able to fit an optimum soft contact lens (Hydron Europe pHEMA standard thickness daily wear variety) within the fitting relationship of $K_f + 1.00 \pm 0.25$ mm.

Non-compliance with any of these features excluded the volunteer subject from participation in the study.

APPENDIX XIII

Checklists - TV System Control Settings

APPENDIX XIIIA

STUDY NO. 1 - Checklist, TV System Control Settings:

1. Switch mains electricity supply on.
2. Select MIRROR mode of display.
3. Select stimulus APPEARANCE = 1.5
4. Select INTERVAL = 2
5. Ensure system not in Hold mode.
6. Ensure CYCLES (stimuli) and PERFORMANCE (responses) LED displays both read 0, zero.
7. Select COUNT mode for Performance display (integers).
8. Select direction of contrast = BLACK stimuli (-)
   or
   WHITE stimuli (+)
9. Select FIVE-POSITION (random) mode of stimulus position on TV screen.
10. Select level of CONTRAST = 1 to 6.

In addition, the glass face of the TV screen should be wiped regularly with a cloth impregnated with an anti-static solution, to ensure that it remains clean and dust-free at all times.

APPENDIX XIIIB

STUDY NO. 2 - Checklist, TV System Control Settings:

1. Switch mains electricity supply on.
2. Select MIRROR mode of display.
3. Select stimulus APPEARANCE = 1.5
4. Select INTERVAL = 2
5. Ensure system not in Hold mode.
6. Ensure CYCLES (stimuli) and PERFORMANCE (responses) LED displays both read 0, zero.
7. Select COUNT mode for Performance display (integers).
8. Select direction of contrast = BLACK stimuli (-).
9. Select FIVE-POSITION (random) mode of stimulus position on TV screen.
10. Select level of CONTRAST = 3.

APPENDIX XIIIC

STUDY NO. 3 - Checklist, TV System Control Settings:

1. Switch mains electricity supply ON.
2. Select MIRROR mode of display.
3. Select stimulus APPEARANCE = 2
4. Select INTERVAL = 3[a]
5. Ensure system not in Hold mode.
6. Ensure CYCLES (stimuli) and PERFORMANCE (responses) LED displays both read 0, zero.
7. Select COUNT mode for Performance display (integers).
8. Select direction of contrast = BLACK stimuli (-).
9. Select FIVE-POSITION (random) mode of stimulus position on TV screen.
10. Select level of CONTRAST = 3.

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a Select INTERVAL = 6, at visit eleven only.

APPENDIX XIIID

STUDY NO. 4 - Checklist, TV System Control Settings:

1. Switch mains electricity supply on.
2. Select MIRROR mode of display.
3. Select stimulus APPEARANCE = 2
4. Select INTERVAL = 3
5. Ensure system not in Hold mode.
6. Ensure CYCLES (stimuli) and PERFORMANCE (responses) LED displays both read 0, zero.
7. Select COUNT mode for Performance display (integers).
8. Select direction of contrast = BLACK stimuli (-).
9. Select FIVE-POSITION (random) mode of stimulus position on TV screen.
10. Select level of CONTRAST = 3.

APPENDIX XIV

Transcripts - Tape Recordings of Instructions as delivered to the subjects in connection with the response procedure which they should adopt in conjunction with the TV stimulus presentation system.

APPENDIX XIVA

STUDY NO. 1 - Transcript, Tape Recorded Instructions:

"I am going to ask you to look at some broken ring shapes which will appear, one after another, in the viewing aperture straight ahead of you. The break in each of the angular rings will occur in one of four positions - either at the top, bottom, right or left. Please note that the position of the break is entirely random at each presentation."

"You have the control box in your hands. Hold it firmly in your lap with both hands, with the word 'TOP' furthest away from you."
(Investigator: confirm correct orientation of hand control box.)
"Each of your thumbs should be poised over two of the four push buttons. When you have identified the position of the break in a ring, press the appropriate button - with a positive on/off action - to indicate your choice. The ring will disappear, to be replaced a few momemnts later by another one. You should respond to this ring in a similar manner."

"The broken rings are of various sizes - some very small, others rather larger. I do not expect you to be able to discern the break in all of them with certainty, but please do 'have a go' and press a single button (only) each time even if, in some instances, you might feel that you are guessing. The score counter on the machine registers correct responses only, so don't worry about disrupting the procedure by an apparent guess. "

"Your response to the presented stimulus will have to be fairly prompt in order for it to register on the scoring device, whether it is in fact correct or not. Do not try to respond to a ring once it has disappeared from the TV screen, and do not try to correct what you felt was a mistake by pressing another button. I appreciate that the process does become a little repetitive, but it is important that you endeavour to maintain full concentration for the duration of the presentation cycle."

"We'll now have several trial runs with the apparatus in order to fully acquaint you with the operating technique. As soon as we both agree that you have mastered the procedure we'll undertake several formal runs, each run being a series of one hundred presentations: this will take about an hour. [X] At each new run I shall be altering the direction and level of contrast of the TV picture. If possible I want you to decide over the course of the experiment which contrast direction - dark rings on light, or light rings on dark - you prefer and feel most confident responding to. [Y] Please feel free to ask for a rest at any time between individual runs."

"Now, if you can position yourself in the chair so that the TV screen appears in the centre of the mirror aperture, let's see how you get on ..."

APPENDIX XIVB

STUDY NO. 2/STUDY NO. 3 (Visits 1, 2 and 12) - Transcript

Transcript of operating instructions identical to those given in Appendix XIVA: Study No. 1, (pages 506-507) but with the omission of the Section [X] - [Y].

APPENDIX XIVC

STUDY NO. 3 (Visits 3 to 10, inclusive) / STUDY NO. 4 - Transcript

"I want you to settle back in the chair and look at the red spot on the large grey screen straight ahead of you. When the auditory cue sounds ..." (Investigator: manually trigger the cue device in order to demonstrate the sound of the auditory signal)" ... I want you to move your eyes (not your head) directly to the viewing aperture at the centre of the grey screer. As soon as you have made this eye movement, a single angular broken ring shape will appear in the viewing aperture: the break in the ring will be in one of four positions - either at the top, bottom, right or left. Please note that the position of the break is entirely random at this and all subsequent presentations."

"You have in your hands the control box. Hold it firmly in your lap with both hands, with the word 'TOP' furthest away from you." (Investigator: confirm correct orientation of hand control box). "Each of your thumbs should be poised over two of the four push buttons. When you have identified the position of the break in the ring, press the appropriate button - with a positive on/off action - to indicate your choice."

"As soon as you have pressed a button, immediately turn your eyes (not your head) back to the red spot and wait for the auditory cue to sound again. When it does, repeat the eye movement, make your response to the new broken ring, and look back to the red spot again. This is all that is required of you."

"The broken rings are of various sizes - some very small, others rather larger. I do not expect you to be able to discern the break in all of them with certainty, but please do 'have a go' and press a single button (only) each time even if, in some instances, you might feel that you are guessing. The score counter on the machine registers correct responses only, so don't worry about disrupting the procedure by an apparent guess."

"Your response to the presented stimulus will have to be fairly prompt in order for it to register on the scoring device, whether it is in fact correct or not. Do not try to respond to a ring once it has disappeared from the TV screen, and do not try to correct what you felt was a mistake by pressing another button. I appreciate that the process does become a little repetitive, but it is important that you endeavour to maintain full concentration for the duration of the presentation cycle."

"We'll now have several trial runs with the apparatus in order to fully acquaint you with the operating technique. As soon as we both agree that you have mastered the procedure we'll undertake several formal runs, each run being a series of one hundred presentations: this will take about an hour. Please feel free to ask for a rest at any time between individual runs."

"Now if you can position yourself in the chair so that the TV screen appears in the centre of the mirror aperture, turn your eyes to the red spot and wait for the auditory cue to sound: the tone will be your signal to start the trial run."

APPENDIX XIVD

STUDY NO. 3 (Visit 11 only : four-point eye movement) - Transcript

"You will see that there are four red spots on the large grey screen ahead of you. I want you to settle back in the chair and look at the red spot in the bottom left hand corner of the large grey screen. When the auditory cue sounds ...."(Investigator: manually trigger the cue device in order to demonstrate the sound of the auditory signal)" .... I want you to move your eyes (not your head) directly to the viewing aperture at the centre of the grey screen. As soon as you have made this eye movement, a single angular broken ring shape will appear in the viewing aperture: the break in the ring will be in one of four positions - either at the top, bottom, right or left. Please note that the position of the break is entirely random at this and all subsequent presentations."

"You have in your hands the control box. Hold it firmly in your lap with both hands, with the word 'TOP' furthest away from you." (Investigator: confirm correct orientation of hand control box). "Each of your thumbs should be poised over two of the four push buttons. When you have identified the position of the break in the ring, press the appropriate button - with a positive on/off action - to indicate your choice."

"As soon as you have pressed a button, immediately turn your eyes (not your head) to the red spot in the top left hand corner of the grey screen, then across to the spot in the top right hand corner, then down to the spot in the bottom right hand corner and finally

back to the original spot in the bottom left hand corner. Wait for the auditory cue to sound again, and when it does look directly to the viewing aperture again, make your response to the new broken ring, and look around the four spots again."

"The broken rings are of various sizes - some very small, others rather larger. I do not expect you to be able to discern the break in all of them with certainty, but please do 'have a go' and press a single button (only) each time even if, in some instances, you might feel that you are guessing. The score counter on the machine registers correct responses only, so don't worry about disrupting the procedure by an apparent guess."

"Your response to the presented stimulus will have to be fairly prompt in order for it to register on the scoring device, whether it is in fact correct or not. Do not try to respond to a ring once it has disappeared from the TV screen, and do not try to correct what you felt was a mistake by pressing another button. I appreciate that the process does become a little repetitive, but it is important that you endeavour to maintain full concentration for the duration of the presentation cycle."

"We'll now have several trial runs with the apparatus in order to fully acquaint you with the operating technique. As soon as we both agree that you have mastered the procedure we'll undertake several formal runs, each run being a series of one hundred presentations:

this will take about ninety minutes. Please feel free to ask for a rest at any time between individual runs."

"Now, if you can position yourself in the chair so that the TV screen appears in the centre of the mirror aperture, turn your eyes to the red spot in the bottom left hand corner of the grey screen and wait for the auditory cue to sound: the tone will be your signal to start the trial run."

APPENDIX XV

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