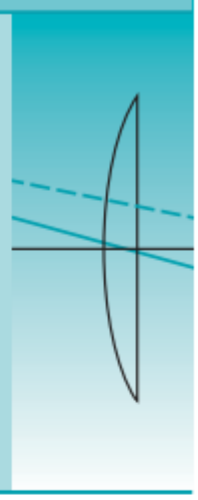
10 EYE EXERCISES FOR HETEROPHORIA



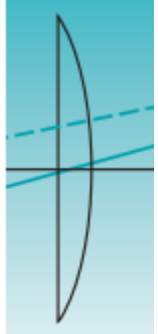
The preceding chapters on various heterophoric anomalies have described the general outlines for the orthoptic treatment of these conditions. This chapter gives details of particular exercises that may be fitted into the aims outlined. For example, the treatment of central suppression is appropriate to several different anomalies. The details of a number of exercises for the treatment of suppression are given below rather than repeating them in several of the previous chapters.

The general principles of eye exercises and the factors to be considered in the selection of patients are described in Chapter 6. A distinction can be made between exercises that provide a smooth, gradual stimulus (ramp) and those that employ a sudden, step-like stimulus (Fig. 10.1). An example of the former is the push-up, 'pencil-to-nose' type of near point of convergence (NPC) exercises. The latter is exemplified by flipper exercises where the patient rapidly alternates fixation between a distant and a near object. Although a few studies support the argument that one of these types is more effective than another, most authors nowadays seem to conclude that orthoptic exercises are more likely to be effective if they employ varied approaches.

Exercises in this chapter will be considered under three main headings:

(1) Development of fusional reserves and relative accommodation
(2) Exercises that train accommodation and convergence in their usual relationship
(3) Exercises for the treatment of central suppression.

Figure 10.1 Schematic illustration of ramp-type exercise (left, e.g. push-up NPC exercises) and step-type (right, e.g. flippers).



The treatment of central suppression has been left until last because, in many cases, this does not require treatment. Sensory adaptations to heterophoria often spontaneously resolve when motor factors have been treated.

Development of fusional reserves and relative accommodation

The aim of the exercise appropriate to each kind of anomaly has been described in the previous chapters for each condition, but the general principles can be summarized as follows:

(1) In esophoric conditions: develop *divergent* reserves and/or positive relative accommodation
(2) In exophoric conditions: develop *convergent* reserves and/or negative relative accommodation.

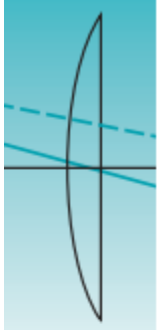
In general, the object of this type of exercise is to exert the fusional reserve while keeping the accommodation unchanged or, the other way round, to induce changes in the accommodation while maintaining fixed vergence. Some methods exercise both, but one function is changed in excess of the other. The intention is to strengthen and increase the function that opposes the troublesome heterophoria and to extend the range of, or to 'loosen up', the accommodation–convergence relationship.

Are fusional reserve exercises effective?

Exercises to increase the fusional reserves are essentially visual-feedback-based neuromotor conditioning or enhancement therapies. The literature on the efficacy of fusional reserve exercises was reviewed by Evans (2001b). In summary, although there is a need for more large-scale studies, the literature does provide some objective (randomized controlled trial) evidence to support the efficacy of fusional reserve exercises. As well as improving the appropriate fusional reserve, the exercises train proximal vergence (Hokoda & Ciuffreda 1983) and may (Bobier & McRae 1996) or may not (Hung et al 1986, Brautaset & Jennings 2006b) increase the AC/A ratio. Most research relates to horizontal fusional reserves, although there is some evidence, from a non-controlled trial, that vertical fusional reserves can also be trained (Luu et al 2000).

What are the essential features of successful exercises?

Fusional reserve exercises can employ a variety of methods of dissociating the eyes, including red/green filters (anaglyph), polarization (vectograms) and haploscopic devices (e.g. stereoscopes). An alternative method, used since 1940 (Revell 1971), is to employ free-space fusion. This has several advantages, including that no specialist equipment is needed. Additionally, recent research has shown that vergence latencies are much shorter,



equivalent to saccades, under free-space conditions, but not when viewing through artificial instruments (Hung 1998). This may support the clinical observation that, when exercises are carried out under more natural free-space conditions, improvements in visual function are more likely to translate into everyday life.

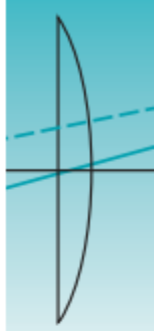
Notwithstanding the method of dissociation, there appears to be two schools of thought regarding the most effective type of exercise. One viewpoint, typified by Vaegan (1979), is that the details of the exercises are relatively unimportant and the key feature is to maintain an overconverged posture for as long as possible. If this hypothesis is correct, then the most important feature of the design of the exercises might be to keep the patient interested during potentially boring periods of overconvergence.

An alternative point of view is that the use of more than one technique may help the effect to transfer into everyday vision (Cooper et al 1983), as may the use of different stimulus parameters (Feldman et al 1993). Stimulus parameters can be varied, for example by using different target types and sizes. Another important factor may be whether the vergence is changed gradually (ramp stimulus) or in jumps (step stimulus). Some studies have found that steps of disparity yield greater improvements than slow ramps, although another study found slow stimulus changes to be optimal (Daum et al 1978). It may be ideal to use both step and ramp stimuli (Ciuffreda & Tannen 1995, p 143). A range of different instruments for orthoptic exercises are available from the American company Bernell (Appendix 11).

Polarized vectogram and anaglyph techniques

With polarized vectograms the eyes are dissociated by means of cross-polarization. The targets are transparent plastic sheets with a picture on each sheet of the same scene but taken from slightly different angles. The sheets are polarized in different directions and the patient wears appropriately polarized glasses. The sheets are back-illuminated by a uniform source and are placed so that the two pictures are directly on top of one another. A non-strabismic patient should report seeing one picture, in three-dimensional relief. To treat an esophoric condition, the sheet that the right eye sees is slowly moved to the right of the left eye's sheet. If the patient continues to report seeing a stereoscopic image then the right eye must have moved to the right to follow the target; i.e. divergence has occurred. The sheet is moved further until the patient reports blur, diplopia or suppression (loss of stereopsis), when the sheet is moved back until binocularity is restored. The procedure is repeated, encouraging the patient to try and maintain binocularity for as long as possible. To train convergence (to overcome an exophoria) the right eye's image would be crossed over to the left of the left eye's image.

A similar technique can be used with anaglyphs, where the eyes are dissociated by means of red and green targets and goggles instead of polarization. Because wearing different-coloured lenses in front of each eye is unnatural, anaglyph techniques are more 'artificial' than polarized vectogram methods. However, dissociation by red/green lenses does allow the



targets to be generated on television or computer screens. As well as increasing the potential for generating different targets, this permits computer control and allows for an automated system of vergence exercises (e.g. Cooper 1988b). An exciting development is the availability of this type of eye exercise on the internet in a system called Orthoweb (Field 2002; Appendix 11).

Haploscopic equipment

Variable prism stereoscopes

A variable prism device, such as a rotary prism, prism bar or the prisms of a variable prism stereoscope, is used in the same way as described for the measurement of fusional reserves in Chapter 4. The patient looks at targets small enough to require precise convergence and accommodation while the power of the prism is gradually increased so as to change the vergence in the direction opposing the phoria. The patient is asked to maintain clear single vision as long as possible, but when blurring or doubling occurs, the prism power is reduced and the patient asked to recover clear single vision as soon as possible. The procedure is repeated for periods of about 5 min. The exercise is carried out for near vision or distance vision, or both, as the patient's difficulties suggest is appropriate.

If a variable stereoscope is used for distance vision, the card holder is removed and the patient looks across the room. For near vision, this instrument can be used either with a single line of letters in the card holder and the septum removed, or using a stereoscope card with separate right- and left-eye pictures and with the septum in place. In the latter case, 9 Δ base-out in each eye will be required. The stereoscope cards appropriate for this should have the majority of the picture common to both eyes so that 'fusion' can take place but have small parts of each eye's picture presented to only one eye to act as 'monocular markers'. In those cases where suppression is particularly marked, this type of card should be used in the early stages of treatment. Note that in all cases the patient should be asked to report that doubling has been observed, in the sense that the target is seen to break into two and the images drift apart. In some cases, double vision may not occur until one of the images has moved outside a fairly large suppression area. In these cases, the target is not seen to double but a second peripheral image suddenly appears; this is most likely in divergence excess exophoria.

A simple variable prism method is to use a prism bar with a target placed at the appropriate distance. This can be loaned to the patient to use at home.

Lens (Holmes) stereoscope

It will be seen from Figure 10.2 that a lens (Holmes) stereoscope can be considered to have two 'orthophoria lines' from the focal point of each of the lenses to a point midway between the lenses themselves. In most stereoscopes, these are purely imaginary lines but are useful in deciding which exercise is appropriate to esophoria or to exophoria. If the two pictures on the stereoscope card are of such a separation and at such a distance that they fall one on each of these orthophoria lines, their images will coincide

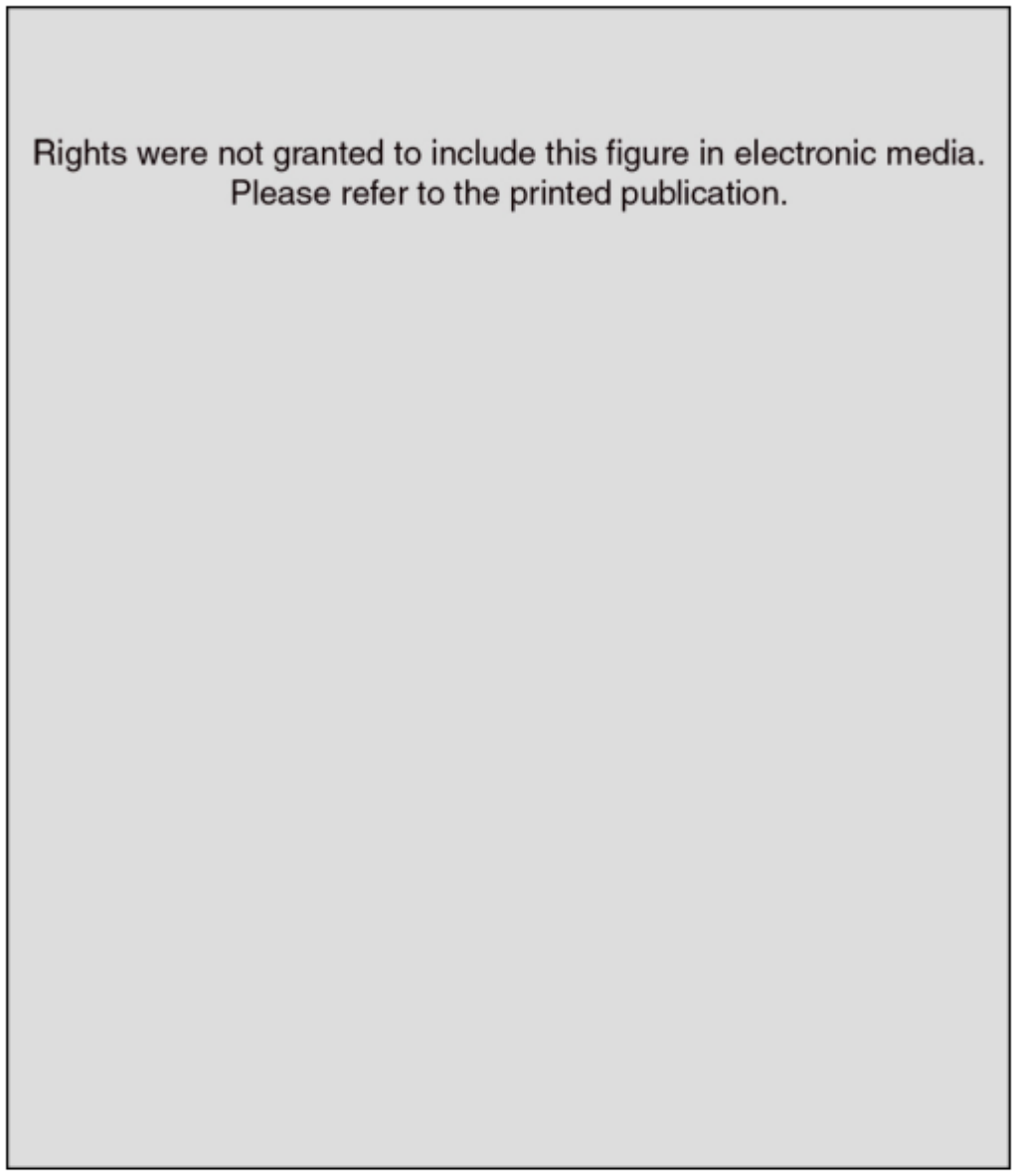
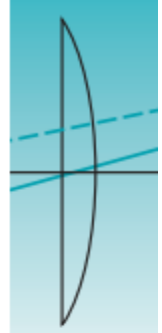


Figure 10.2 The principle of the Holmes stereoscope. Two lenses, L_R and L_L, are separated by a distance, *d*, that is greater than the patient's pupillary distance, so that a base-out prism effect is produced. A septum at *ss* prevents the right eye from seeing the left image and the left eye from seeing the right image. The pictures, O_R and O_L, on the card C_1 are held at a distance *l*. If these pictures are separated by a distance, *p*, such that they lie on the two lines joining the focal points of the lenses, F'_1 and F'_2, with the midpoint between the lenses, A (the 'orthophoria' lines), the images of the pictures, O'_L and O'_R, will coincide on the midline at a distance *l'*. The eyes should then have to exert accommodation and convergence in the normal relationship for looking at an object at *l'* (ignoring proximal convergence). If the pictures lie outside the orthophoria lines, forced divergence will be required for single vision. Such forced divergence, which is required as an exercise in esophoric conditions, can be achieved by either increasing the picture separation, *p*, or by decreasing the card distance *l*. Similarly, the forced convergence required in exercises for exophoric conditions can be produced by decreasing the picture separation or by increasing the card distance; e.g. moving the card to C_2. (After Lyle & Wybar 1967.)



with each other on the midline of the instrument. This will mean that, ignoring any proximal convergence, the eyes will have to converge and accommodate according to the normal accommodation–convergence relationship for the particular distance of the images. To use a card with a greater picture separation, but at the same card distance, would require the eyes to diverge in order to 'fuse', and a card with less picture separation would induce convergence. No change in accommodation would be required.

Figure 10.2 also shows that, if the card distance is increased without changing the separation of the pictures, i.e. the card holder is drawn away from the patient's eyes, the picture separation will now be narrow for the new card distance and therefore convergence will be required to maintain 'fusion'. In this new position, the card's picture will lie inside the orthophoria lines. At the same time, the image distance will have increased, so that less accommodation will be required. This means that, when the card distance is increased, convergence and negative relative accommodation will be exercised, which will help patients with exophoric conditions. In summary, when using the Holmes strereoscope:

(1) in esophoric conditions: use cards of increasing picture separation and/or move the card holder *towards* the patient's eyes
(2) in exophoric conditions: use cards of decreasing picture separation and/or move the card holder *away from* the patient's eyes.

Other stereoscopic devices

There are many different designs of stereoscope. A well known one is the Brewster stereoscope, which is fairly similar to the Holmes design. A currently available Brewster stereoscope is the Bernell-O-Scope (Appendix 11).

A slightly different approach is to use apertures rather than lenses to achieve dissociation, as in the Bernell Aperture Rule (Fig. 10.3). A single aperture is used to train relative convergence and two apertures are used to train relative divergence.

Mirrors can also be used to dissociate the eyes, as in the single mirror haploscope, which is consulting-room equipment. A new version of the Pigeon–Cantonnet stereoscope, which is a portable instrument employing mirrors, is available as the Bernell Mirror Stereoscope (Appendix 11).

Synoptophore

Exercises of the fusional reserve type can also be carried out with a major haploscope using 'fusion slides'. The restricted field, stimulation of proximal convergence and other disadvantages of this type of instrument do not seem to affect the building up of fusional reserves. However, this major instrument is hardly necessary for heterophoria problems.

Free-space techniques

Free-space techniques do not require a stereoscope but involve the fusion of two stereo-pairs by overconverging or underconverging in 'free space'.

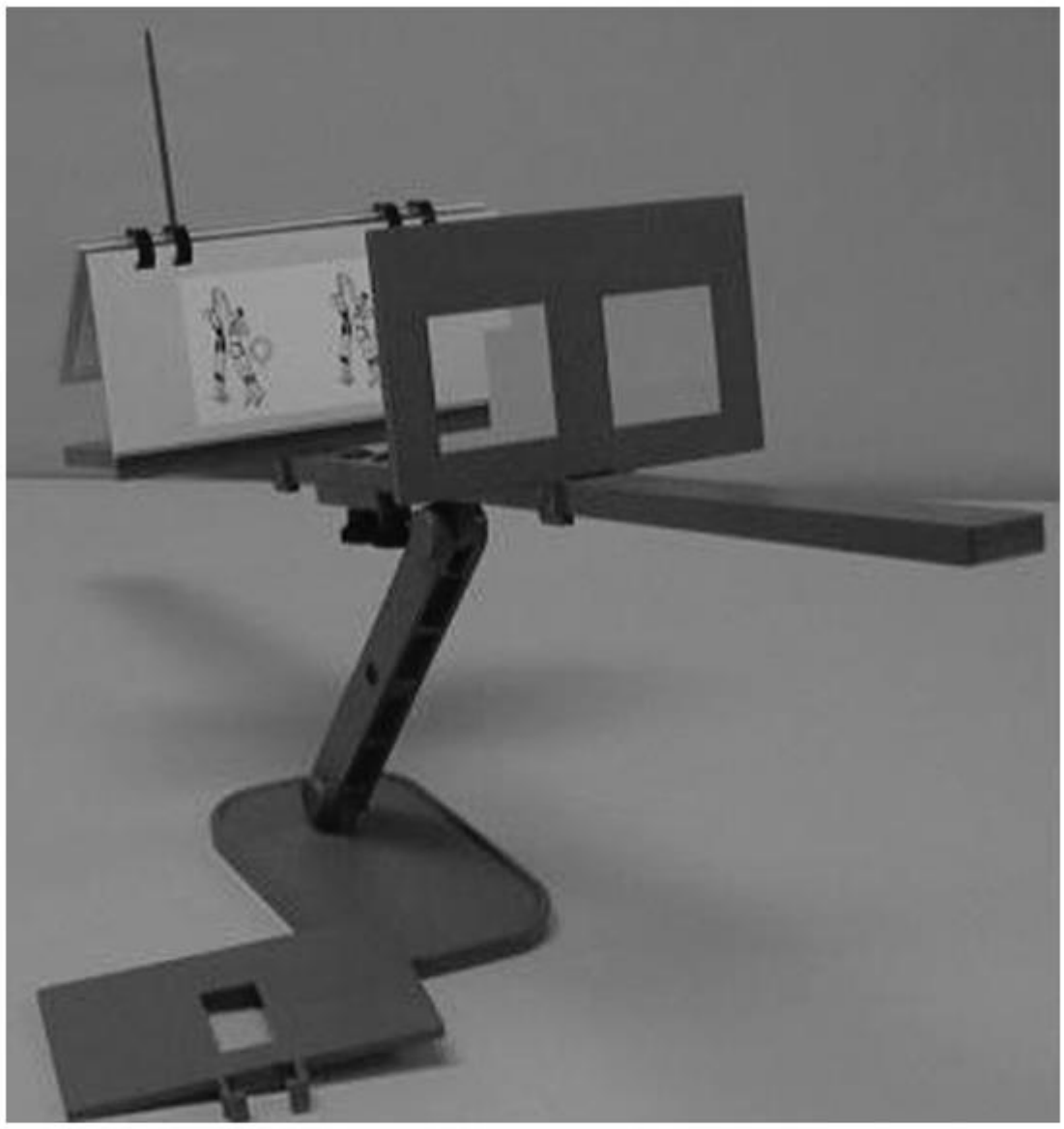


Figure 10.3 Bernell Aperture Rule, with the double aperture used to train relative divergence (see text for description). (Reproduced with permission from Vision Training Products, Inc. (Bernell Division).)

Physiological diplopia

One feature of free-space techniques is the use of physiological diplopia and it will be seen that there are a number of ways in which physiological diplopia can be useful in the treatment of heterophoria. The first step with any of these exercises is to demonstrate physiological diplopia and the easiest method is to use two fairly large and obvious objects as targets, for example two pencils. These objects are held on the median line against a plain background (Fig. 10.4). The demonstration should include the patient fixating the nearer pencil and noticing the far pencil in uncrossed physiological diplopia, and then fixating the far pencil and observing the near one in crossed diplopia. Difficulty in seeing both the diplopic images indicates a fairly gross degree of suppression, which is usually overcome quite quickly in heterophoria. However, many patients may have difficulty in

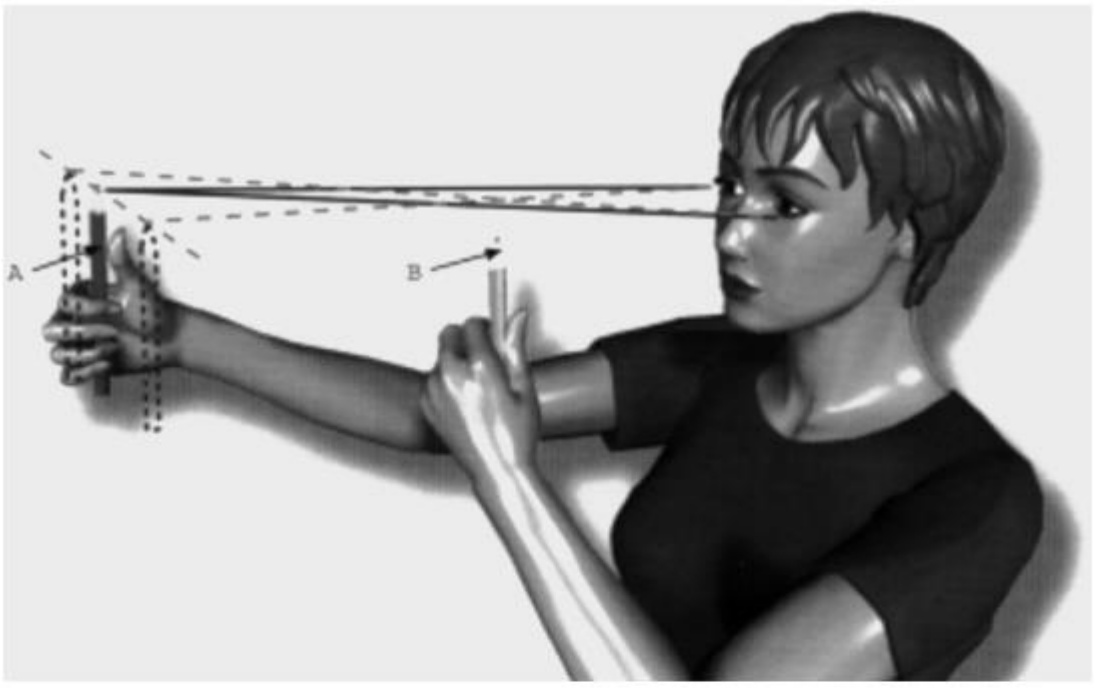


Figure 10.4 Physiological diplopia: the patient fixates the further pencil A and notices that the nearer pencil B is seen in crossed physiological diplopia: the right eye's image on the left and the left eye's image on the right. A change of fixation to the nearer pencil should result in the farther one being seen in uncrossed physiological diplopia. For details of exercises, see text.

alternating between uncrossed and crossed diplopia. In these cases, it is useful to ask the patient to practise doing this alternation as an exercise; this is described below on page 150. Once patients have mastered the principle of physiological diplopia with pencils, they can progress to other free-space techniques. Probably, the simplest of these is the 'three cats' exercise.

'Three cats' exercise

The equipment for this exercise is simply a piece of card with two line drawings of cats side by side separated by about 5 cm from centre to centre. Each cat is incomplete in some way, an ear, an eye or the tail is missing, say, so that only when the two are fused is a complete cat formed (Fig. 10.5). This method does not require a stereoscope.

The exercise is particularly useful for exophoric conditions when used in the following way (Fig. 10.5). The card is held at about 40 cm from the patient's eyes, and the patient is asked to fixate the point of a pencil held midway between the card and the eyes. The card will then be seen in physiological diplopia: four cats instead of two. A slight adjustment of the distance of the pencil will enable the middle two cats to be fused into a complete cat with an incomplete cat on each side: the three cats. The patient is then asked to try to maintain fusion and to see the cats clearly. This requires convergence to the distance of the pencil but exerting accommodation only for the greater distance at which the card is held. This exercises the negative relative accommodation. With practice, a clear view of the three cats can be

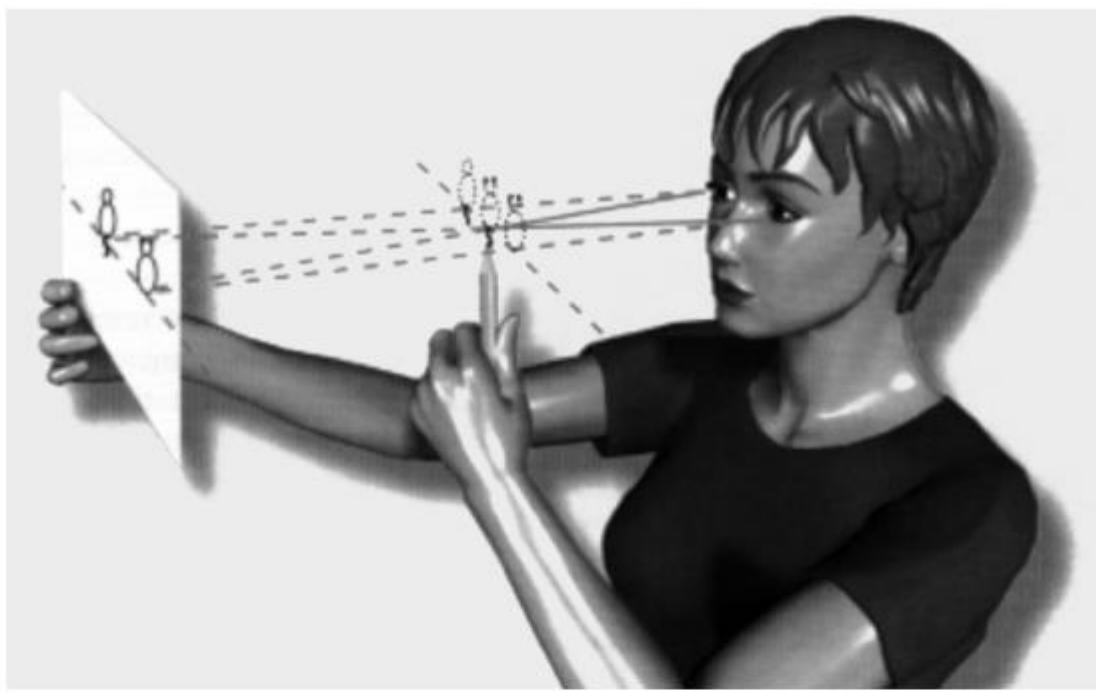


Figure 10.5 'Three cats' exercise. The card with drawings of two incomplete cats is held at arm's length. The patient fixates a pencil held between the card and the eyes. Physiological diplopic images of the cats will be seen as blurred images, and the pencil distance is adjusted until the middle two cats fuse into a complete cat, with two incomplete cats one on each side. The resultant percept is of three cats. The patient is asked to try to see the cats clearly, to converge for the pencil distance and to relax accommodation, i.e. to exercise negative relative accommodation.

maintained even when the pencil has been removed. Many patients can teach themselves to exercise voluntary convergence, or 'go cross-eyed', and obtain fusion of the cats without the use of a pencil.

The process of converging to achieve fusion of two laterally separated targets, such that the right eye fixates the left target and the left eye the right target, is sometimes called *chiastopic fusion* (Goss 1995, p 159).

This exercise can also be used for esophoric conditions but patients tend to have more difficulties initially. It is easier if the card is cut between the cats and the exercise is started with the cats very close together. With esophoria, the patient is asked to fixate a distant object just over the top of the card, with the card held at about 30 cm before the eyes. When physiological diplopia of the two pictures on the card is appreciated, the card distance is adjusted to obtain fusion of the middle two picture designs. Fusion is maintained as the card is moved upwards slightly and thus obscures the initial fixation object. An alternative method is to photocopy the card on to a plastic transparency and to instruct the patient to literally look through the cats at the distance object. It is likely that the cats will appear very blurred at first, but the patient should concentrate on maintaining fusion with underconvergence rather than clear vision at this stage. When this can be done, it is useful in obtaining clear vision if the card is moved away from the eyes to about 40 cm, where clear vision may be easier. When the patient can clearly see a fused middle picture with an incomplete one each

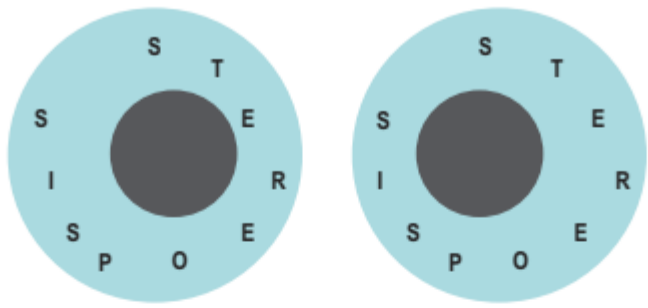


Figure 10.6 An example of a free-space stereogram. The exercise is carried out in the same way as the 'three-cats' exercise but the patient enjoys stereoscopic vision as feedback that the exercises are being performed correctly.

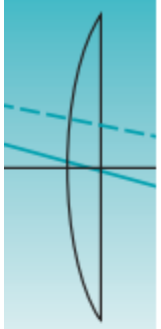
side, then the patient is exercising the positive relative accommodation, i.e. accommodating for the card distance while maintaining vergence appropriate to distance vision. This is not a very easy exercise to use with esophoria and it may be more useful to start with haploscopic equipment.

When undertaking the three cats exercise, it is very easy for exophoric patients to discover how to obtain fusion into the three cats by underconverging or for esophoric patients to fuse by overconverging. That is, patients do the exercise the wrong way round and if this is undetected they can be exercising the wrong function. The practitioner may be able to check for this by watching the patients' eyes as they do the exercise, and parents can also be taught to do this. The card should be held straight, since if the two cats are at significantly different heights then fusion will be impossible. Occasionally, it may need to be tilted slightly to keep the images at the same height.

Free-space stereograms

Any stereoscope card can be used in a similar way to the three cats exercise to train positive or negative relative accommodation, or suitable targets can be drawn easily with modern computer drawing programmes. Targets should be chosen that allow a check for suppression. This can be achieved either by having detail that is unique to each half (picture) of the stereo pair or by using a target that gives stereoscopic relief (Fig. 10.6). Stereoscopic targets may be preferable for two reasons. First, they give the patient some feedback, a positive perception of stereopsis, to encourage them and to assure them that the exercises are helping their vision. Second, the direction of the perceived stereopsis can be used to check that the patient is converging or diverging as appropriate.

Patients' perception can be checked by monitoring their perception of the size of the targets, using the mnemonic 'SILO' (small in, large out). This refers to the movement of the eyes ('in' during convergence): if patients are exercising their convergent fusional reserve then as they converge the target should appear to be smaller and closer. The opposite effect should be seen if patients are exercising their divergent reserves. However, occasionally patients are encountered who demonstrate the opposite perception to that expected (Hokoda & Ciuffreda 1983).



Once patients have mastered free-space stereograms using simple line targets, the exercises can be further developed using autostereograms. These are a type of free-space stereogram that were developed from the work of Julesz (1971) with random dot stereograms. Books of these pictures can be obtained, which can be used as an entertaining form of vergence exercise. As with any free-space exercise, patients may automatically tend to do the exercises incorrectly (e.g. exophores will find it easier to see a stereoscopic image when diverging). Care should be taken to ensure that the correct type of vergence movement is being used and all patients should be closely monitored to confirm an improvement in their binocular status.

A series of free-space stereogram exercises for training convergent fusional reserves have been developed at the Institute of Optometry and these include simple targets and free-space stereograms. These are described on page 156.

An advantage of many free-space techniques is that they utilize physiological diplopia: the two outside pictures (e.g. the two outside cats in the 'three cats' exercise) are seen in physiological diplopia. By maintaining an awareness of these images during the exercises, some of the benefits described below from physiological diplopia exercises will be produced.

Prisms in free space

Prisms can be used in free space, for example from a prism bar, as described on page 69.

Facility training

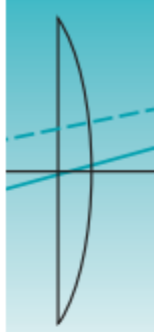
Vergence facility (prism flippers)

The 'flip prisms', or prism flippers, consist of two pairs of prisms mounted on a horizontal bar, one pair (base-in) on the top of the bar and the other pair (base-out) below the bar (see Fig. 2.5). One pair of prisms can be held before the eyes and then quickly changed to the other pair by a simple flip movement.

Patients should be able to change their vergence and maintain accommodation as the prism is changed from base-in to base-out and back again (p 72). Exercising with flip prisms is carried out by asking the patient to look at a card with letters printed on it and held at about 40 cm while the prisms are flipped from base-in to base-out and back. Patients should practise with 3 Δ base-in and 12 Δ base-out total prisms until they can execute 20 complete cycles per minute. This is known as testing the vergence facility.

Accommodative facility (lens flippers)

Accommodative facility can be tested and exercised by flip lenses of, for example, +2.00 DS/−2.00 DS. With abnormal patients, it is important to monitor any suppression while this is taking place and a suitable target for this is the vertical fixation disparity test of the near Mallett unit (see Fig. 4.3). Disappearance, but not movement, of a Nonius strip is significant; the flip lenses should only be 'flipped' when the patient reports that the



OXO is clear and single and that both Nonius strips are present. As a home exercise, it is adequate to use the flipper with a normal page of print at the usual reading distance and to check for suppression at each visit of the patient to the practice. This 'flipper' exercise should be carried out for a few minutes several times a day. Patients usually respond in 1–2 weeks.

The normal result for a group of typical pre-presbyopic patients is 7.7 cycles per minute (one cycle is positive to negative and back to positive), with a SD of 5 (Zellers et al 1984).

Patients with accommodative problems may also benefit from this type of exercise. This may be indicated in three functional accommodative anomalies:

(1) *Accommodative infacility (inert accommodation):* the accommodation responds only slowly to changes of fixation and the patient reports that, when looking from near to distance vision, or the other way, objects come into focus only after a short delay. This can also be an early sign of spasm of accommodation caused by excessive amounts of work at too close a working distance, often accompanied by uncorrected hypermetropia (convergence excess esophoria in Ch. 5). If patients only report that distance is slow to clear after near vision then this can be a sign of a myopic change in their refractive error.

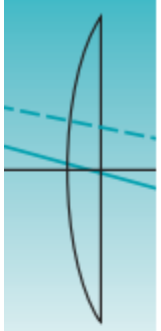
(2) *Accommodative insufficiency*, in which there is a low amplitude of accommodation for the patient's age, in spite of there being no uncorrected hypermetropia.

(3) *Accommodative fatigue* is indicated when a patient reports that accommodation cannot be sustained for long periods of near vision, but reports blurring after a short time. Again, this may be a symptom of uncorrected hypermetropia and attention should be given to this before embarking on a course of exercises.

In all three cases the patient needs to have a correction for any significant hypermetropia before eye exercises for accommodative dysfunction. Active pathology as a cause of the accommodative problem should also be ruled out (e.g. infectious or neurodegenerative diseases, toxicity, glaucoma, diabetes, Adie's syndrome, trauma; Cooper 1987, p 436), as should the antimuscarinic effects of some systemic medications (Thomson & Lawrenson 2006). Patients who will respond to the flip lenses type of exercise are usually in the age range 10–25 years and this type of exercise has been validated by controlled trials (Rouse 1987, Sterner et al 2001). The exercise can also be preceded by a 'push-up' exercise, carried out as if repeating the measurement of amplitude of accommodation.

Exercises that train accommodation and convergence in their usual relationship

It is sometimes useful to use procedures that exercise the accommodation and convergence in their normal relationship. It seems that decompensated



heterophoria may be associated with difficulty in interpreting the cues which stimulate the appropriate degree of vergence change. In these cases, the disparate images of an object not at the fixation distance (in physiological diplopia) are misinterpreted. A patient with convergence excess esophoria, for example, when asked to change fixation from a near object to look at one slightly further away from the eyes, will make a divergent movement only with one eye. This will leave the eyes in the position of a temporary convergent strabismus. Suppression and abnormal correspondence may be produced, leading to a more permanent strabismus (Gillie & Lindsay 1969). This occurs mainly in young children before the binocular reflexes are firmly established, i.e. earlier than the age of 7 years. Such patients may benefit from general coordination exercises, which are based largely on teaching a correct interpretation of physiological diplopia.

Older patients may also benefit from procedures that exercise the accommodation and convergence in the normal relationship. These are cases in which either the convergence or the accommodation amplitudes are low and may be improved by 'push-up' type exercises or near–far 'jump' exercises (described below).

Physiological diplopia

The patient is taught a proper appreciation of physiological diplopia by using two objects held on the median line against a plain background (Fig. 10.4). The exercise consists of fixation of one pencil, pausing long enough to be sure that it is single while the other is in physiological diplopia and then changing fixation to establish single vision of the other with diplopia of the first. This alternation of fixation should not be carried out too fast or confusion results; there should be a 3 s pause at each change to ensure that the correct interpretation has been made. At first, the patient's eyes should be observed to see the steady and regular change of vergence of both eyes.

When this can be carried out successfully using isolated objects like the two pencils or two knitting needles against a plain background, the patient can be taught to appreciate physiological diplopia at any time by holding up a pencil or a finger and noticing the doubling of objects beyond. A change of fixation to the distant object will produce diplopia of the pencil.

In cases of convergence insufficiency, the nearer object is held at 40 cm from the eyes in the first place but gradually moved closer as the patient is able to alternate between near fixation with uncrossed physiological diplopia and distance fixation with crossed diplopia. By this procedure, the patient is encouraged to perform the jump convergence test, with the nearer fixation object starting at 40 cm and gradually moving closer to the eyes to the 10 cm position.

The bead-on-string exercise, described later in the chapter, is also very useful as a home exercise and is an extension of the physiological diplopia principle (see Fig. 10.10).

Pencil-to-nose (push-up) exercises

These exercises have been found useful in exophoric conditions and in convergence insufficiency for many years. This type of exercise can be essentially a variant on the physiological diplopia exercise above. The patient is asked to look at a pencil placed at about 50 cm or well outside the range of the near point convergence. It is then moved towards the eyes until it appears double or the practitioner (or parent) sees that one eye has ceased to converge. This is repeated until the amplitude of convergence is closer than 10 cm. The patient is urged to 'make the eyes pull' to keep them converged on the near target as it approaches. If diplopia is not appreciated as soon as the practitioner notices that one eye has ceased to converge, then the patient should be taught to perceive physiological diplopia of some distant object. The patient should monitor the increased separation of these images as the pencil is brought closer to the nose and start moving the target back out when one of the diplopic images disappears. Sometimes preliminary exercises for suppression are required before the pencil-to-nose exercises.

Near–far 'jump' exercises

Pencil-to-nose exercises are a 'ramp' type of exercise and should be complemented by a 'step' type of vergence (and accommodative) exercise. The patient moves a small, detailed target in as close as possible towards the nose before it goes blurred, double or one eye diverges (observed by the practitioner or by a parent). The patient holds the near object still but relaxes accommodation and convergence by looking at a distance object until this distance object has become clear and single. The patient then looks at the near target and, once this is clear and single, back at the distance target. This 'near–far' cycle is repeated as quickly as possible (but only when the targets are clear and single) for about 10 min at least twice a day. Typically, the near target will be some small print, which should be regularly changed so that it is not memorized. As with pencil-to-nose exercises, this exercise can be combined with an appreciation of physiological diplopia.

Exercises for treatment of central suppression

In heterophoria, suppression is mostly confined to a small foveal area and is usually intermittent. Only where there is a long-standing intermittent strabismus, as in divergence excess, will a larger suppression area be present. Where suppression is demonstrated in heterophoria, it is treated first or at the same time as any vergence treatment. As will be seen, some of the techniques described above for treating fusional reserves and general coordination can also be used at the same time to treat foveal suppression. In many cases the suppression will resolve spontaneously when the motor

deviation is treated. Where it does not, all or some of the following exercises may be appropriate.

Stereoscope cards

Several stereoscope cards have been designed for the treatment of suppression in heterophoria. These usually consist of 'fusion' cards, in which most of the design is common to both eyes but some of the detail is presented to one eye only. The patient is asked to look at the fused design and ensure that the part of the total picture presented only to the eye with a tendency to suppress is seen and is retained without intermittently disappearing.

Physiological diplopia

It has already been seen that there are many ways in which physiological diplopia can be useful in the treatment of heterophoria. First, it should be demonstrated that the patient can appreciate physiological diplopia as described in the first section of this chapter.

When the patient has appreciated physiological diplopia with the pencils, foveal suppression can be treated by using thinner targets such as a straightened length (about 15 cm) of wire. This is interposed between the eyes and a page of print (Fig. 10.7). This is the *wire reading* method. Initially, it is placed at the mid-distance from the eyes to the page, so that it is seen in physiological diplopia with two images apparently separated by 1–2 cm.

The patient is asked to read the page, slowly moving the wire along to keep the word being read midway between the two diplopic images and

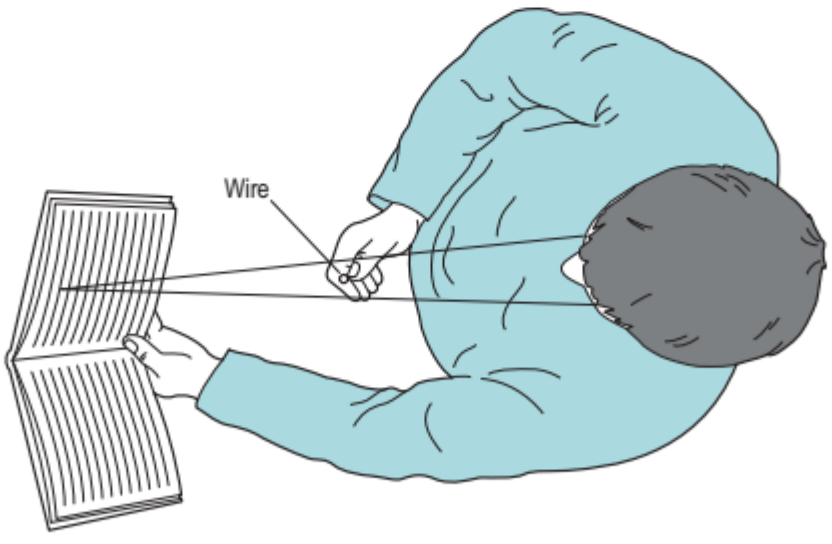


Figure 10.7 Wire reading: a thin rod or length of wire is held on the median line between the printed page and the eyes. When fixating a letter on the page, the wire is seen in crossed physiological diplopia unless there is suppression. As the patient reads, the wire is moved across the page to maintain the two images at equal distance on each side of the point of fixation.

being conscious of both images all the time. When this is done, the wire is moved slightly nearer to the page so that its images appear closer together and more into the central suppression area. The patient should be asked to practise this exercise for several 10 min periods each day for 1–2 weeks (Earnshaw 1960). In the case of children, the exercise needs to be supervised by a parent to ensure that they do not forget to maintain a check that both diplopic images are there, otherwise interest in the book may absorb all their attention.

Bar reading is a further extension of this exercise (Fig. 10.8). In this case, the patient uses a thicker object – a pencil is appropriate but an even thicker object can be used. If a pencil is interposed between the eyes and the book, it should be about one-third of the distance from the eyes. This will ensure that it acts like a septum, occluding a vertical strip of the print from each eye. In this exercise, the pencil is held still on the median line and is not moved along the line as in the previous method. As the patient's eyes cross the page during reading, the beginning of the line is seen by both eyes. There is then a strip occluded from the right eye by the pencil but visible to the left if there is no suppression. Then there is a strip of the page seen by both eyes, before the pencil occludes the left eye. The end of each line of print may be seen by both eyes.

Unless there is suppression, the patient should be able to read across the page without being aware of the pencil occluding either eye. At first, the patient may have to make a conscious effort to 'see through' the pencil in the position where it occludes the dominant eye. It is important that during the exercise the head is held quite still. If patients experience difficulty in the exercise, small movements of the head will be noted as they try to look round

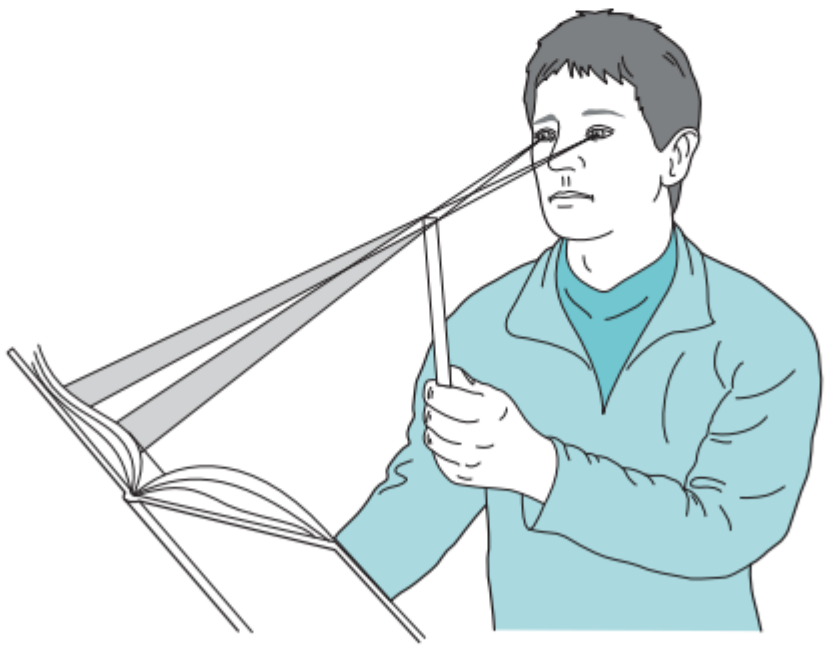


Figure 10.8 Bar reading: a slightly wider septum is held a little closer than midway between the page and the eyes. It is kept still on the median line so that it occludes a different part of the page from each eye. The patient must use both eyes to be able to read across the page.

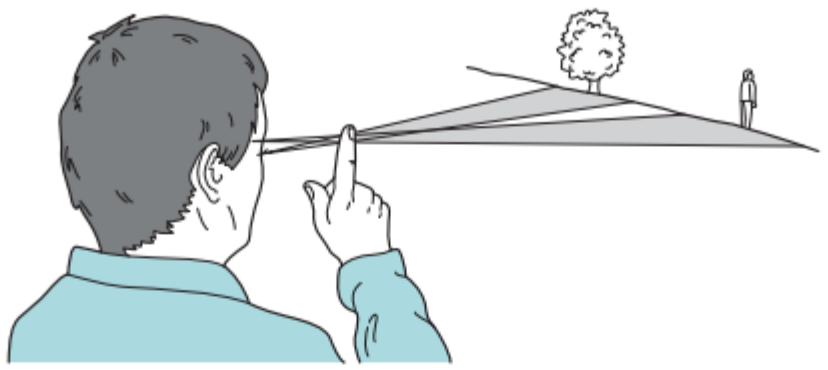


Figure 10.9 A septum for exercising simultaneous vision for distance vision. The finger (or a septum) is held about 10 cm from the eyes while the patient looks at a distant scene. The patient should be aware of physiological diplopia of the finger and that both images are apparently transparent; that is, an object can be seen 'through' each finger; e.g. the tree and the man. The patient alternates fixation from one subject to the other, pausing at each to ensure that both objects and images of the finger are still visible.

the pencil. A parent or friend may need to watch that this does not happen. An anaglyph (red/green) bar reading approach is also available (see below).

If the suppression is present mainly for distance vision, the *septum test* (Fig. 10.9) can be modified to provide an exercise. The patient holds a finger, or other object of about the same width, 10–20 cm from the eyes while looking across the room or out of a window for distance vision. It is noticed that the 'septum' occludes objects in the visual field from each eye. The patient is asked to identify these objects by closing each eye in turn or by occluding each with the other hand, e.g. the tree and the man in Figure 10.9. Then, with both eyes open, the patient is asked to look first at one of the objects and then at the other, alternating between the two. The head and hand must be kept quite still during this and the patient is asked to concentrate on seeing 'through' the finger each time there is a tendency to suppress. The exercise can be demonstrated in the consulting room using a distance of 6 m and two objects about 75 cm apart; the finger is moved nearer to the eyes or further away to obtain the best position.

The *bead-on-string* (Brock string) exercise can be used to combine near and distance vision exercises (Pickwell 1971, 1979b). A length of string is tied at one end to a suitable object several metres from the patient and the near end is held close to the nose so that the patient looks down the length of the string (Fig. 10.10). A piece of card with a different-coloured patch on each side is seen in crossed physiological diplopia to check for gross suppression. A bead or small hexagonal metal nut is threaded on the string and serves as a movable fixation target. The string should be seen in continuous physiological diplopia with the 'two strings' appearing to cross at the fixation, i.e. through the bead or nut. Any suppression is indicated by the lack of seeing part of one of the two strings; closer than fixation in the case of exophoria and beyond fixation in esophoria. The fixation bead or nut can be moved along the string to check for suppression at all distances. With a little practice the patient can move fixation along the string

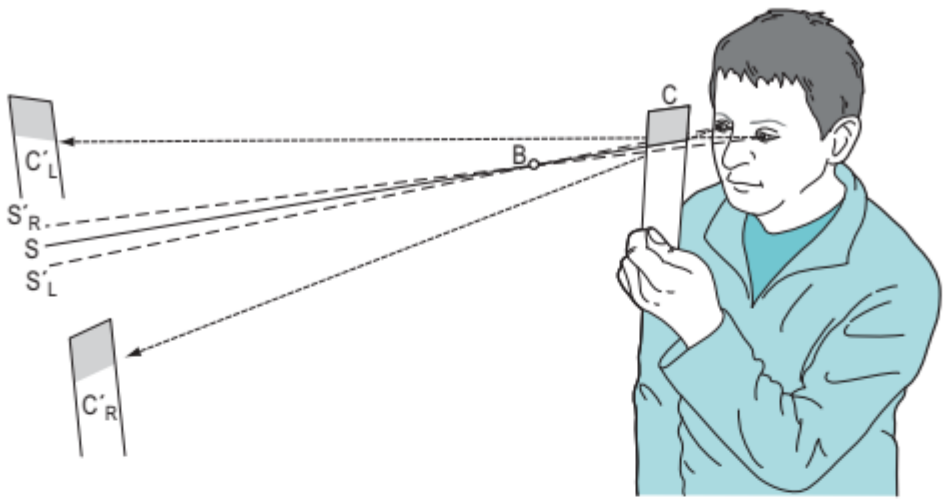


Figure 10.10 Bead-on-string exercise: the patent holds a card, C, close to the nose. A length of string, SBC, tied to the card and to some more distant object, stretches horizontally. A bead, B, acts as a fixation object. The patient, fixating the bead, should see the card in crossed physiological diplopia: if it is a different colour on each side, it helps identification of the crossed diplopia. The string will be seen in increasing uncrossed diplopia beyond the fixation point, S'_R and S'_L, and in increasing crossed diplopia between the fixation bead and the eyes, i.e. the string should appear as two strings crossing through the bead. In suppression, part of the cross will not be seen. For details of the exercise, see text.

without having to move the bead or nut and can maintain a continuous check on suppression at all distances.

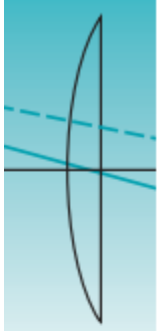
Note that this procedure does not exercise relative convergence or accommodation, as the accommodation and convergence are changed together. It may, however, assist in heterophoria cases where the patient has difficulty in appreciating physiological diplopia correctly: this was discussed earlier in the chapter. The bead-on-string exercises can also be useful for treating severe cases of convergence insufficiency.

Some forms of free-space stereograms include features that are designed to detect and treat suppression. Fine detail, some of which is specific to each eye's image, will aid the treatment of foveal suppression. This feature of the Institute Free-space Stereogram exercises is described below.

Red and green filters

If the eyes are dissociated by placing a red filter before one eye and a green one before the other while the patient looks at a small spot of light, any suppression will show as an absence of one colour. Normal patients will see one light, which is a mixture of red and green in retinal rivalry. In unstable heterophoria, two lights may be seen and where there is suppression one of these may be present only intermittently. A prism of 6 Δ base downwards before one eye will produce vertical diplopia, and suppression is more easily overcome.

In this exercise, the prism is rotated slowly toward the base direction in which it relieves the heterophoria; base-in for exophoria or base-out for



esophoria. The patient will see the two lights rotate round each other and move closer together as they become level and the prism relieves the phoria. As the images move into the central foveal suppression area, one colour will disappear. The prism base–apex line is turned back towards its original base-down position and the patient tries to see the missing colour. The patient can have red and green filters and a prism on loan to practise this at home. This exercise is particularly useful in divergence excess cases.

Another approach that uses dissociation achieved by red and green filters is anaglyph bar reading. A coloured overlay that has alternating vertical strips coloured red and green is placed over the page. Patients wear red/green glasses and, as they read along a line some of the text is only visible to each eye, so that suppression has to be overcome.

An example of combined exercises: the IFS exercises

Introduction

The Institute Free-space Stereogram (IFS) exercises were developed at the Institute of Optometry (see ethical declaration in Appendix 11) to train convergent fusional reserves and negative relative accommodation and to treat foveal suppression in heterophoria (Evans 2001b). The exercises were designed to keep patients in an overconverged posture for as long as possible while keeping them interested and amused with a variety of tasks and different stimuli (Table 10.1). The various targets and types of stimulation (step and ramp) may help the benefit translate into everyday life. An open trial of over 20 consecutive patients produced encouraging results (Evans 2000a). The exercises are designed to be used at home, employing a parent and child team. They can be used by adults or older children by themselves but these patients should be warned that some of the instructions are phrased in 'child friendly' language.

The principle of free-space stereograms is more than 50 years old, although the IFS exercises have been designed with an awareness of recent research. A key feature of the exercises is very detailed instructions to make the parent, or older patient, the 'vision therapist'. The instructions are arranged in a series of stages to enhance a sense of progress for both the patient and parent. Usually, several stages are progressed through each day and this encourages the participants.

Patients are asked to do the exercises for 10 min twice a day. The exercises can also be effective if only done for 10 min a day but are then likely to take longer to complete. It is far preferable to have a short period (e.g. 3 weeks) of concentrated exercises than to try and continue for much longer. Even 3 weeks is quite a long time for a child and it helps if, when the exercises are issued, the child is aware that a check-up appointment has been booked in 3 weeks time so that they have a clear date to work towards.

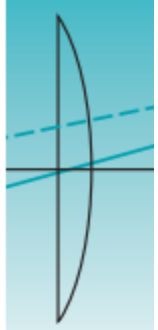


Table 10.1 Details of goals and design of IFS exercises

Goal	*Design feature*
Affordable	Printed home exercises
Easy to understand	Comprehensive instructions
Fun to do	Novel 3-D images Varied tasks
Motivating	Encourage parent/child team One or two 10 min sessions daily Check in 3–4 weeks
Checks on progress	10 self-test questions
Variety of stimuli	18 targets with step and ramp Different size stimuli Different shape stimuli Vergence angles: 3–30 Δ
Control/treat suppression	Physiological diplopic images Monocular markers Stereopsis

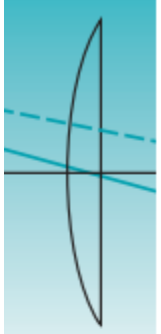
Design of the IFS exercises

The IFS exercises comprise four cards, which the patient views, and detailed instructions that are read out by the parent or by the patient if old enough. Practitioner instructions are also included.

Card 1

Card 1 introduces the patient to the concept of physiological diplopia, starting with a simple target of two dots. The instructions train the patient to fixate a pencil above the page to cause overconvergence. Patients are taught to appreciate the page as being doubled, so that they see four dots. The distance of the pencil is then adjusted and they are taught to be aware of the two pairs of dots moving until the innermost dots become superimposed. Once they have practised this they progress to a similar exercise, but with rings. At this stage the patients experience depth perception and this tends to rejuvenate interest. They progress to more dramatic stereopsis, although the separation of the targets on this card is small, so that only a mild degree of overconvergence is required.

Quite early on in Card 1 the patient experiences the first of 10 self-test questions. These ask patients about their stereoscopic perception, to confirm that they are making appropriate vergence movements. If not, then they are instructed to stop the exercises and to consult their eyecare practitioner.



Card 2

Card 2 uses targets with a very marked stereoscopic relief. In addition to the conventional 'ring' targets, there are also several shapes that are seen to 'float in three-dimensional space' (Fig. 10.11). Throughout this card, the need to keep the targets clear is stressed, which exercises negative relative accommodation.

A variety of different techniques are used on Card 2 and there are again regular self-checks to ensure that the patient is overconverging and not overdiverging. The awareness of physiological diplopia and stereopsis should help to reduce any suppression but there are also special targets that are designed to treat foveal suppression. With these small targets, the patient sees a four-limbed star (✳) but with some of the limbs seen only by each eye. Thus, any suppression is revealed and the patient is taught to overcome this. The patients then progressively 'jump' down to the lower set of rings and repeat the exercises with those. Because these become further apart they require greater degrees of positive relative convergence.

After spending some time concentrating on the stereoperception of each target, patients are then instructed to rapidly track down the page, overconverging as appropriate for each successive target. This represents a form of 'step' (phasic) exercises, rather like using prism flippers. In the final stage for Card 2 patients are taught to gradually move the page towards them while maintaining an overconverged posture. This represents a form of 'ramp' (tonic) exercises.

Cards 3 and 4

To maintain patient interest, Card 3 employs a different approach. It uses an autostereogram that has been specially created for the exercises (Fig. 10.12). Autostereograms are pictures based on random dot stereograms and the principle and history of the development of these has been summarized by Thimbleby & Neesham (1993).

Autostereograms can be viewed by converging or by diverging, so great care is taken in the IFS instructions to ensure that only convergence is used by patients during the exercises. Patients are taught to first exert positive relative convergence to obtain a stereoperception and then exert negative relative accommodation to make the elements of the stereogram clear. When the stereograms are viewed appropriately, patients perceive a series of steps, leading up towards them. As 'their eyes walk up each step' they converge by increasing degrees. On each step is a letter, and the patient has to identify this and record the result. There are the usual 'self-checks' to ensure that the exercises are being performed correctly, and the result is recorded for the practitioner to check at follow-up appointments. As with the rest of the exercises, the instructions clearly guide the patient through the stages of this phase of the exercises.

Card 4 is another autostereogram and follows a similar principle to that used in Card 3.

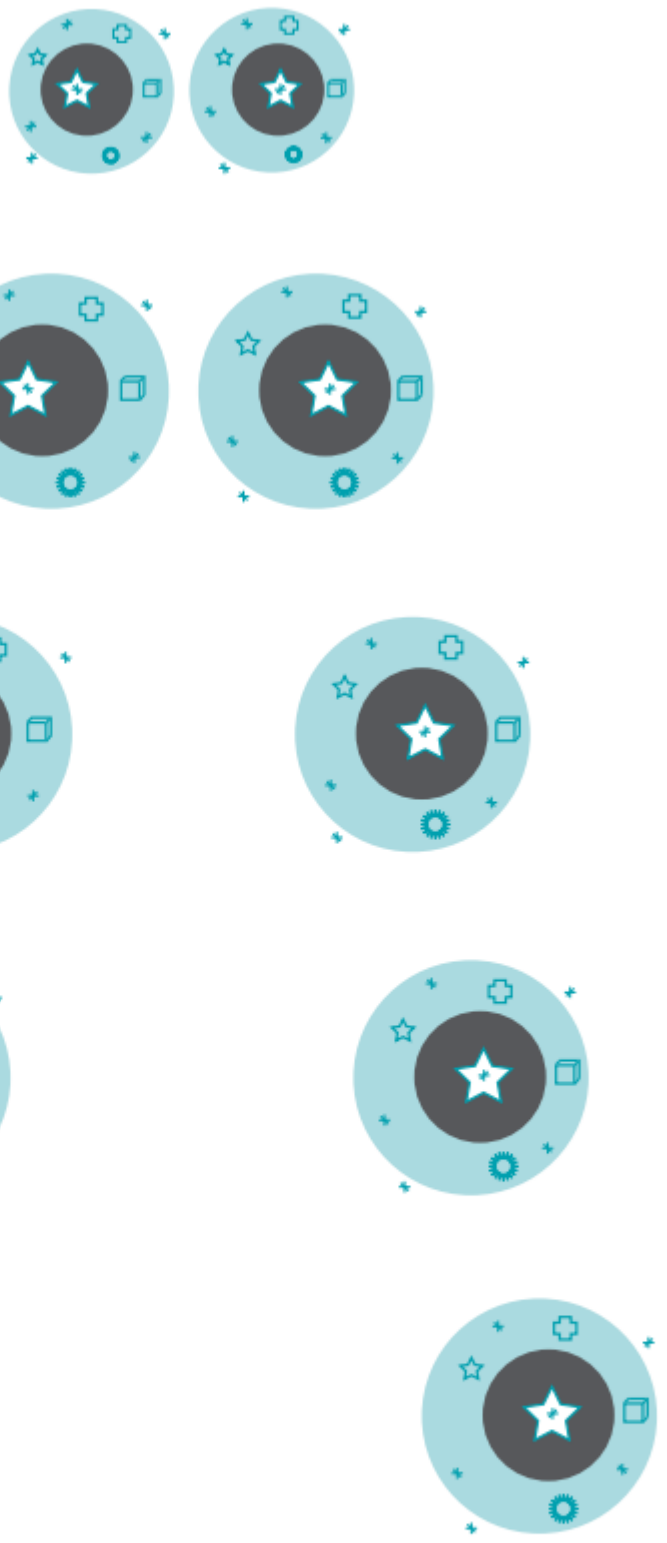


Figure 10.11 IFS Card 2. The actual card is A4 size, larger than shown.

Patient selection

The most common use of the IFS exercises is to treat decompensated exophoria at near (Case study 10.1). They can also be used to treat convergence insufficiency, some cases of decompensated basic exophoria, intermittent near exotropia and (for more experienced practitioners) constant exotropia

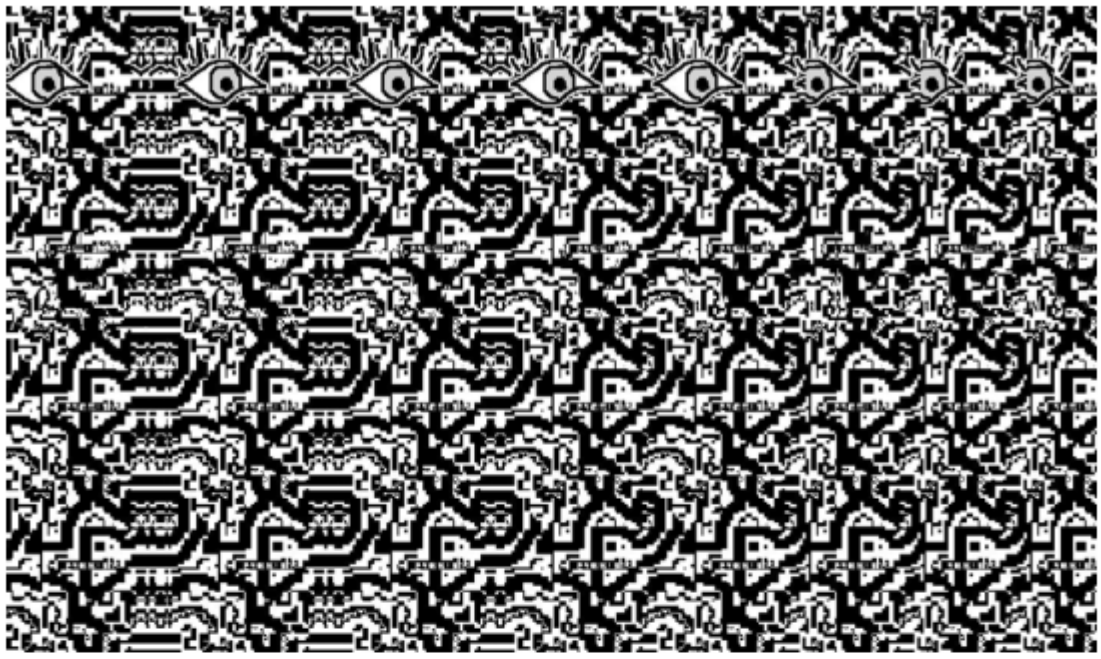


Figure 10.12 IFS Card 3. The actual card is A4 size, larger than shown. The autostereogram was created by Altered States, a developer of custom-designed autostereogram images.

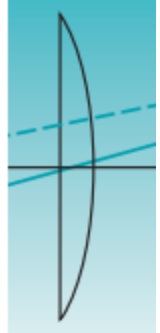
at near. For many patients the IFS exercises are the only treatment that is needed. With other patients, particularly those with strabismus, the IFS exercises can be used as part of a complete treatment regimen, supplementing other exercises described elsewhere in this chapter.

As with any form of eye exercises, patient selection is crucial. If the patient or parent lack enthusiasm for exercises then they are very unlikely to work and other options should be considered, such as refractive modification (Ch. 6). The IFS exercises are most likely to be effective in patients over the age of 10 years (Evans 2000a), and can be effective in older patients (Case study 10.1).

Issuing the exercises to the patient

One of the main objectives of the IFS exercises is to allow home orthoptic therapy without the need for much input from the eyecare practitioner. The exercise booklet can usually be dispensed to the patient without lengthy explanations. Parents need to be told that the exercises require teamwork and a quiet time and place for the parent to read the instructions and for the child to view the cards.

Patients are told that there are self-checks and that they can telephone the practitioner if they are concerned. They are also warned that the exercises will be hard work so that a few minor symptoms of sore, tired or aching eyes are to be expected for the first few days. The instructions warn that, if these symptoms persist or if any blurring or diplopia occur, then the patient should stop the exercises and consult the practitioner. Typically, a follow-up appointment is booked in 3 weeks.



CASE STUDY 10.1 Ref. E5380

BACKGROUND: Insurance broker aged 61 years, wearing bifocals with minimal distance correction and +2.00 add. General health good, no medication.

SYMPTOMS: Last few months when reading eyes feel sore and tired and non-localized headache about twice a week after day in office.

CLINICAL FINDINGS: *Normal:* visual acuities, refractive error (minimal hypermetropia for distance, +2.25 add), visual fields, pupil reactions, ophthalmoscopic findings, ocular tensions, anterior segment, D ocular motor balance, NPC (4 cm). N cover test 6 Δ XOP with poor recovery. N aligning prism (with correction) 2.5 Δ in L. N convergent fusional reserve − /8/6 Δ.

MANAGEMENT: Discussed decompensated exophoria and possibility of prism in glasses or eye exercises. Patient preferred to have eye exercises and given IFS exercises. Re-exam advised in 4 weeks.

FOLLOW-UP: Found exercises easy, done for 20 min a day. Symptoms 'cleared up' and no headaches. N cover test 4 Δ XOP with good recovery. N aligning prism (with correction) 0.5 Δ in LE. Convergent fusional reserve 26/34/18. Exercises stopped, to return if more symptoms.

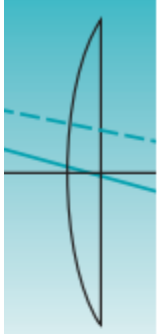
FOLLOW-UP 18 MONTHS LATER: No symptoms (broken glasses), results as at last appointment except for aligning prism now zero.

Follow-up

Very rarely, patients telephone the practitioner to report a problem with the exercises. The problems they might report and solutions to these are given in the practitioner instructions.

At the follow-up appointment, after 3–4 weeks, the practitioner should enquire about how easy or difficult the exercises have been, how often they been done and for how long on average each day (Case study 10.1). The patient should be asked about any change in their initial symptoms and whether any new symptoms have occurred.

The relevant clinical tests should be repeated and the results compared with those obtained before giving the exercises. If the symptoms and clinical signs have improved then the exercises can be stopped (Case study 10.1). Occasionally, the exercises need to be continued for a little longer. If there has been no or very little improvement then alternative approaches need to be considered, as discussed elsewhere in this chapter and in Chapter 6. If the exercises have been successful then the patient is asked to keep the booklet in case further 'top-up' exercises are required. Most older patients recognize the return of their symptoms and initiate a further session of exercises themselves. Of course, patients should be warned that if symptoms persist they should return. Younger patients may need to be re-examined, perhaps in 3 months, to check the clinical signs. Patients can be reassured that top-up exercises are usually much easier and briefer.



Clinical Key Points

- Exophoric conditions are treated by training convergent fusional reserves and/or negative relative accommodation
- This generic type of exercise has been validated by randomized controlled trials
- Fusional reserve eye exercises are most likely to be effective if they
  - are interesting for the patient
  - use a wide range of targets with both step and ramp stimuli
  - teach an appreciation of physiological diplopia
  - employ feedback (e.g. stereopsis)
  - allow simultaneous training of any foveal suppression
  - are carried out intensively with a follow-up appointment in 3–4 weeks
- Various methods of dissociation can be used, including stereoscopic devices, red/green filters, polarization, and free-space methods
- Facility training can also be helpful