Biofeedback AND Binocular Vision

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ABSTRACT

Biofeedback is discussed and some general and optometric applications are indicated. Feedback and its use in vision therapy is demonstrated by means of several simple procedures for use in amblyopia and strabismus.

KEY WORDS

biofeedback, binocular vision, vision therapy, orthoptics, amblyopia, strabismus

The following is a discussion on biofeedback: what it is, how it has been used and how the principles of biofeedback can be applied in the area of binocular vision without the need for highly sophisticated instruments.

Most optometrists who are working with disorders of binocular vision are already using biofeedback during therapy. When, for example, we use anaglyphs and a Brock string and ask a patient to form a cross, composed of the red and green strings over a target such as a pen, we have created a situation in which visual feedback is being provided by means of the strings and pen. Biofeedback is basically the process whereby information about usually unconscious biological activities under the control of the autonomic nervous system becomes available to consciousness. This information can then be used to modify behaviour, treat illness and relieve stress. In the visual system what are these unconscious biological activities under the control of the autonomic system? We know that one is the accommodative system; another is pupillary dilation and constriction; and a third is lachrymal gland tear secretion.

Usually in biofeedback an instrument is used to monitor some biological activity, such as heart rate, and then to convert this information into a display or signal which can be used to modify the selected biological activity. Instrumentation is, however, not always necessary and it is of major importance that the learnt skill shows generalisation and retention during daily activities and this may often require "out-of-instrument" procedures, such as visualization and relaxational techniques.

In the visual system we know that in a binocular individual accommodation and oculomotor function are closely integrated and that when we exceed the range of binocular fusion, diplopia, confusion or suppression occurs. Likewise, if we exceed the range of binocular accommodation about a point in space, blur of the target is seen. These changes in the visual system inform us and the patient about internal biological activity and the clarity and singleness of sight itself are the displays or signals that can be used to modify this internal activity.

The following quotation is from "Stress and the Art of Biofeedback" by Brown:[1] "Between the information input and the resulting learned physiological control, extraordinary complex information processing must occur, where appropriate information to the brain is associated, integrated, evaluated, put into memory and the product of this brain activity is used to activate patterns of neural activity that result in discrete channeled directions to control the selected physiological activity." According to Brown,[1] biofeedback has been used in more than 50 different types of major medical and psychological problems with either greater success than conventional treatment or at least with equal benefits. Patients have been taught to exert voluntary control over heart rate, blood pressure, muscle tension, brain waves, skin temperature, vasoconstriction and dilation and other internal biological functions capable of being monitored. The general applications of biofeedback include: hypertension, bruxism (the grinding of teeth), asthma, intestinal disorders (ulcer, colitis, spasms, diarrhea, incontinence), menstrual distress, muscle spasms, stroke, paralysis, tension, migraine and chronic headaches, learning problems, hyperactivity, insomnia, alcoholism, and drug abuse, anxiety, phobias and depression, cerebral palsy and spasticity, epilepsy, chronic pain and tinnitus.

In optometry, biofeedback has been used, for example, to train voluntary control of accommodation, and Ferri,[2] as reported by Trachtman,[3] has shown a 0.50 D to 0.75 D reduction in functional myopia with auditory and visual biofeedback.

Patients have been taught to use feedback to improve monocular ductions[4] and to learn smooth eye movement control and to improve monocular cyclorotary eye movements, as reported by Halperin and Yolton.[5] These studies showed, as we already know, that there is a high degree of plasticity and trainability in the human oculomotor system.

Biofeedback has also been used in strabismus.[6] The current trend involves monitoring the eyes directly and feeding back information on eye position to the patient. Objective ways to monitor eye position include electro-oculography (EOG), photo-electro-oculography (PEOG), television systems, and electromagnetic coil monitoring. To monitor eye position with the EOG, surface electrodes are placed on the skin at the inner and outer canthus and changes in the electrical potential of these electrodes are measured as the eye moves back and forth between them. In the PEOG, infrared beams are directed towards the eyes and the reflections are monitored. The differing reflections of the sclera and cornea/iris are detected by sensors. With television-based systems, the eyes are viewed by a camera and the image is processed electronically to give an indication of the line of sight (eye position). These devices are very accurate but also very expensive. The magnetic coil system has a scleral contact lens with a metallic ring embedded in it. The patient's head is placed in an electromagnetic field and as the eye turns the scleral ring generates a change in the field. Biofeedback is a useful treatment for many strabismic patients and it has been suggested that it can be used to the exclusion of home therapy and even conventional in-office visual therapy.

Research on nystagmus has shown that it is possible to reduce the amplitude, frequency and velocity of nystagmoid eye movements with auditory biofeedback.[7] Halperin and Yolton[5] refer to the work of Ishikawa, Tanakadate, Nabatame and Ishii,[8] which showed a short-term transfer effect to "out-of-instrument" settings. However, conclusive evidence of a long-term transfer is lacking.

Biofeedback has also produced improvement in amblyopia and eccentric fixation, and has also been used in the treatment of glaucoma and blepharospasm.[5]

DISCUSSION

At present in South Africa, in optometry, instrument biofeedback does not appear to be in frequent usage. Instrument biofeedback obviously has a role to play but non-instrument biofeedback may have some advantages. It is less expensive, it can be used by the patient in the "out-of-office" situation, and the skills, although perhaps initially harder to learn, might show greater generalisation and retention.

At this point, I will briefly demonstrate how I incorporate feedback into some therapy procedures. In general my approach is the standard one in which one moves from monocular through biocular to binocular procedures, using larger less detailed peripheral stimuli initially and later smaller, more centrally detailed stimuli. I also feel that effective therapy consists of both office and home therapy and that patients should demonstrate proficiency in the techniques suggested for home use while under supervision in the office. Just what type of feedback are we as optometrists able to use during therapy? We can use visual, auditory, tactile and kinesthetic feedback quite easily. Lenses, prisms and mirrors will change the patient's visual world and produce changing visual feedback. Simply closing one of the patient's eyes or using a filter in front of one or both eyes changes the patient's visual world and feedback. Changing targets and their distances, sizes, hues, movements and illumination changes visual feedback. We can instruct the patient to use his hands, thus involving tactile feedback. Metronomes, buzzers and bells provide auditory feedback and time and rhythm become involved here. Our voices and instructions can be used very effectively to provide suitable auditory feedback. Movement of the patient's head or body changes kinesthetic feedback. We can put the patient on a walking rail or balance board and again change kinesthetic feedback.

I would like briefly to describe a few simple procedures which I use in treating amblyopia and strabismus. These are only an aspect of the treatment plan that one would develop for each patient but they will demonstrate how feedback can easily be used during therapy.

In amblyopia I usually use partial occlusion with either nail varnish or translucent tape in front of the non-amblyopic spectacle lens or, if the patient cooperates, I rather partially and simultaneously occlude the non-amblyopic eye (so as to allow this eye to be used at distance only) and partially occlude the amblyopic eye (so as to allow this eye to be used for near activities only). I place the occlusion on the non-amblyopic spectacle lens in a high position (i.e., from the bottom frame rim to middle pupillary line) so as to try to discourage the patient from using this eye for near activities. In non-compliant patients other methods may be necessary. The patient is to use the occlusion as much as possible, especially if vision in the amblyopic eye is very poor or sensory adaptations are deeply embedded. In some instances I use occlusion only intermittently where sensorimotor adaptations are less embedded, but, generally, I prefer not to allow the patient to function in his "old" learnt manner in between the office and home therapy sessions if this is at all possible. I then like to emphasize therapy that involves accommodative, oculomotor and eye-hand coordination skills in which changes in head and body movement are involved. The approach is firstly to emphasize monocular activities in an attempt to equalise the functions of the two individual eyes, and thereafter biocular and binocular procedures are performed.

One of these monocular techniques involves either cardboard or transparent plastic cards which the patient holds at a distance just exceeding that patient's nearpoint of accommodation (NPA). The types of cards that I typically use include those shown in Figure 1.

The patient must then count the number of dots or visually trace the pathways or read the letters. Patients can, of course, construct their own cards for home use. The card provides a visual stimulus to the patient and the state of clarity or blur provides visual feedback to the patient. This procedure can also be used in accommodative insufficiency and here the card is again used at a point just further away than the patient's NPA. The patient is then instructed to keep the target (for example, letters, dots, etc.) clear for as long as possible. The time can be measured using a stopwatch. When the target blurs the patient is to refocus it and again attempt to keep it clear for as long as possible. An increase in time and, therefore, accommodative sustainability is sought. The NPA should also shift towards the nose if any increase in accommodative amplitude occurs. I also encourage the patient to relax accommodation voluntarily, that is, to see the near target blurred. A transparent plastic card and a distant target is useful during this procedure. Cycles for near- far focus can be determined over a time interval and monitored during training with the aim being to increase the speed of these cycles. A modification of this technique is to move the card smoothly into different positions of gaze while the patient fixates on a target and the card is at about the NPA or alternatively patients can move their heads while keeping the card still. The technique can also be used while the patient is standing on a balance board. These techniques place a great demand on the accommodative system and thus ciliary muscles, since they are performed at a point close to the patient's nearpoint of accommodation.

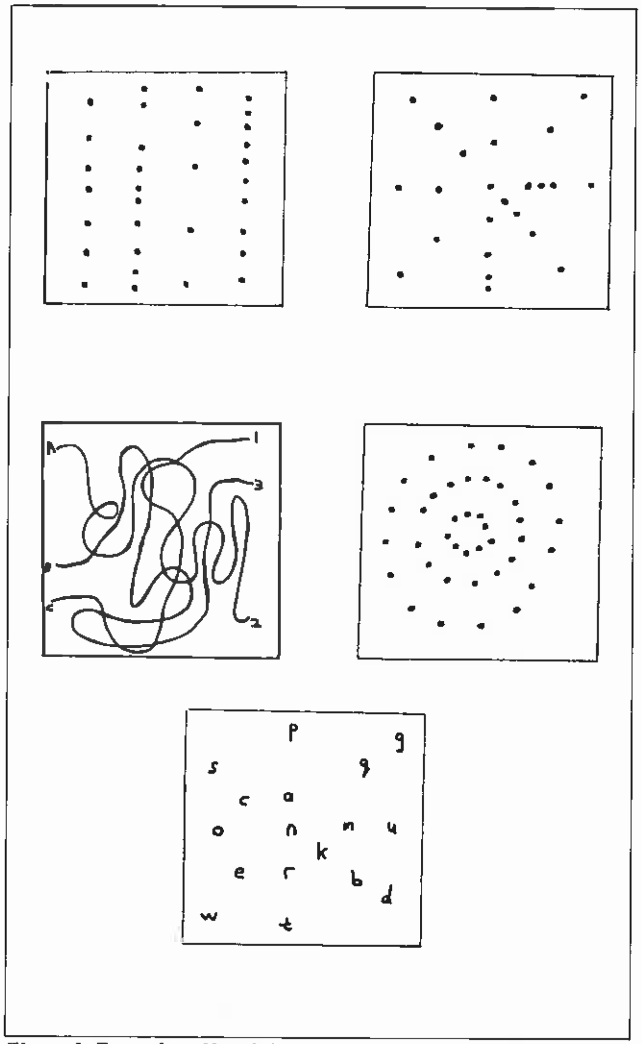

*Figure 1. Examples of hand-drawn **nearpoint cards used by patients.***

Another monocular technique uses a Marsden ball with auxiliary prism and a pointer. The ball is moving and the orientation and power of the prism is changed and the patient must touch various targets on the moving ball with the pointer. The targets I like to use are smallish circles of different colours and the patient must touch the pointer in the middle of the circles. By changing the prism, the position of the ball appears to have moved in space and this is a useful procedure to teach spatial projection of the eye. The patient is receiving visual, tactual and kinesthetic feedback and it is very simple to include auditory signals and balance boards as well.

During these procedures I emphasize to the patient that he or she should breathe fully and rhythmically and should increase the level of relaxation of the muscles of the rest of the body, especially if they notice that they are beginning to become tense. Sometimes I teach methods to increase general muscular relaxation if I think this is necessary. A simple technique is for the patient to sit or lie in a comfortable position. Then he tenses a specific muscle group and creates a visual image in the mind of the area of the body concerned but in a relaxed state rather than a tense one. He relaxes the muscle group concerned while feeling the changes in muscular tension and maintaining the mental image. The patient then proceeds to repeat this with other muscle groups.

Other techniques I use in amblyopia include plus and minus lens procedures, tracing exercises at near using pen, pencil and felt-tip pens, red and green projection torches with or without prism, and anaglyphs which are also useful. If patients are able to appreciate them, I also sometimes use Haidinger brushes or afterimages which provide good feedback.

In strabismus I also emphasize procedures which use feedback. One which is useful also in anti-suppression therapy and in anomalous retinal correspondence (ARC) is described here. The patient wears either Bagolini lenses or a single red or green anaglyph or both anaglyphs and is directed to a target which can be at any distance. The target can be a penlight, or a flashlight (the glass is covered with frosted scotch tape to get a more even light distribution over the surface) can also be used, or a vertical projected line on the distance screen (with or without letters), or a vertical short white line or circle on a black card at near or on a black piece of cardboard at distance. Target size can thus be modified and therapy can begin with large peripheral targets and gradually smaller, more central targets can be used. The patient then reports what is seen and may give a suppression or ARC response. A loose Fresnel prism is introduced in front of one eye and typically the patient will report seeing two lights, lines, or circles. I have found that diplopia is usually reported and if it is not immediately seen, by then occluding the eyes alternatively and showing the patient the individual targets, on opening the two eyes again the patient is able to find the target, which previously disappeared when he looked binocularly. Sometimes, by moving the prism (for example, rotating it or changing the base direction), the diplopic images can be seen. Once the patient is aware of the two images, voluntary alignment of the images can be taught with or without the aid of auxiliary lenses or prisms. Sometimes I use the prism base vertical and the patient must align the two images one above the other. Otherwise I use base-in or base-out according to the direction of the strabismus and the patient must fuse the two images to form a single image and show luster or a Bagolini cross. The patient must then maintain luster, vertical alignment or the cross during head and later body movement and when the prism is removed, and then replaced. Walking rails and balance boards and auditory signals can be incorporated. The technique can also be used without the anaglyphs and can be combined with afterimages in various forms, including the Hering-Bielschowsky type.

The procedure is useful in that suppression is readily reported and, by using the cover test when the patient reports luster, a cross or vertical alignment, any movement of an uncovered eye indicates the presence of ARC. The use of Bagolini lenses or a single red or green anaglyphic lens in front of one eye makes it easier to use the cover test than if one uses both anaglyphs together. The patient will still have a luster effect since one eye sees a white target and the other sees a red or green one. It is also useful because of the versatility with which the visual percept (or feedback) can be alterd by changing the target and the power or orientation of the auxiliary Fresnel prism and is very useful for home therapy. The technique can be performed using prism bars or loose prisms. It can also be used after neutralizing the patient's objective angle of deviation with prism. It provides the patient with a cortical awareness of the projection of the two eyes and thus of eye position, which the patient can then use to produce sensorimotor fusion of the two eyes to obtain clear, single binocular vision.

CONCLUSION

Thus we can see that most of the therapy techniques we use involve visual and often other types of feedback, and that optometry has a strong role to play in non-instrument biofeedback because of the facility with which these techniques can be applied to the visual system. When we talk about our success in treatment of binocular disorders, I think that this is largely because of the biofeedback that we typically use and I am confident that optometry will continue to develop even more effective biofeedback procedures in the future.

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Presented at the Binocular Vision Seminar at Cathedral Peak Hotel on the 12th March, 1989

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