Patterns of abnormal binocular fixation in a symptom free subject with a well controlled exophoria

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ABSTRACT

A case history is presented that illustrates six different patterns of binocular fixation in a symptom free subject with a moderate exophoria or convergence weakness type, following a vergence eye movement. This 19 year old student showed normal vergence resulting in binocular fixation, but also showed an insufficient vergence response, two types of saccadic responses, an unequal vergence response, and a response where one eye converged for near fixation while the other eye remained fixing for distance. Similar responses to these have been described by others in apparently normal subjects, who may represent a symptom free group able to make ready sensory adaptations to abnormal binocular fixation. Alternatively, the lack of diplopia in the presence of significant retinal disparity may be the result of a normal form of visual suppression that occurs briefly during, and just following a vergence eye movement, similar to that which occurs during a saccade.

INTRODUCTION

If a person has a well controlled heterophoria, normal ocular movements, full convergence and good stereoacuity and has never complained of symptoms, the expectation of most clinicians is that such a person would make normal convergence and divergence eye movements that result in bifoveal fixation. Any deviation from this would result in symptoms such as diplopia, blurred vision or general asthenopia. A case is presented of such a subject who shows a range of abnormal vergence movements without any diplopia or symptoms.

SR is a 19 year old university student, who presented as a volunteer for a study on normal vergence eye movements. She had visual acuity of 6/6 in each eye, a well controlled exophoria of 10^{Δ} for near and 4^{Δ} for distance, normal ocular movements, and stereoacuity to 40" on the Titmus Test. Her left eye failed on convergence at 6 cms, with diplopia. Her base out prism fusion amplitudes held at 45^{Δ} for near and distance, and her base in ranges were to 8^{Δ} for distance and 20^{Δ} for near, with diplopia noticed when fusion failed. She was not aware of her heterophoria, having never experienced symptoms of eyestrain or diplopia . She presented during a university Summer School, an intense six week study period, having just completed one year of her university course.

METHODS

A computer based video eye movement system was used to measure the subjectís eyes as she made convergence and divergence changes of 5°, 10° and 15° along the midline. The 'far' target was 2m from the eyes, the closer targets were at 52 cms, 30 cms and 21 cms from the eyes. The head was stabilised with a bite bar.

The measurement device consisted of an IBM compatible PC and a video on which two monochrome infra-red sensitive CCTV video surveillance were mounted. Two ìhot mirrorsî reflected the infra-red image of the eye to the cameras

The video images of each eye were adjusted to give maximum contrast that clearly identified each pupil. Horizontal and vertical eye positions could then be calculated by tracking the center of mass of the largest black object (the pupil) in each binary video image and converting its position into gaze angles using geometric transformations and calibration procedures. During recording sessions the video images tracked by the system could be viewed by the examiner, who noted the unusual responses described opposite.

RESULTS

SR had at least six different types of response to a vergence stimulus, these are illustrated in figures 1-6.

Figure 1 shows a normal response to a 10° stimulus. In this example the slight separation of the traces for distance fixation represents a small error of complete divergence, but this is within normal limits.

In all figures, the lower solid circles represent movements of the right eye, the upper open circles represent movements of the left eye.

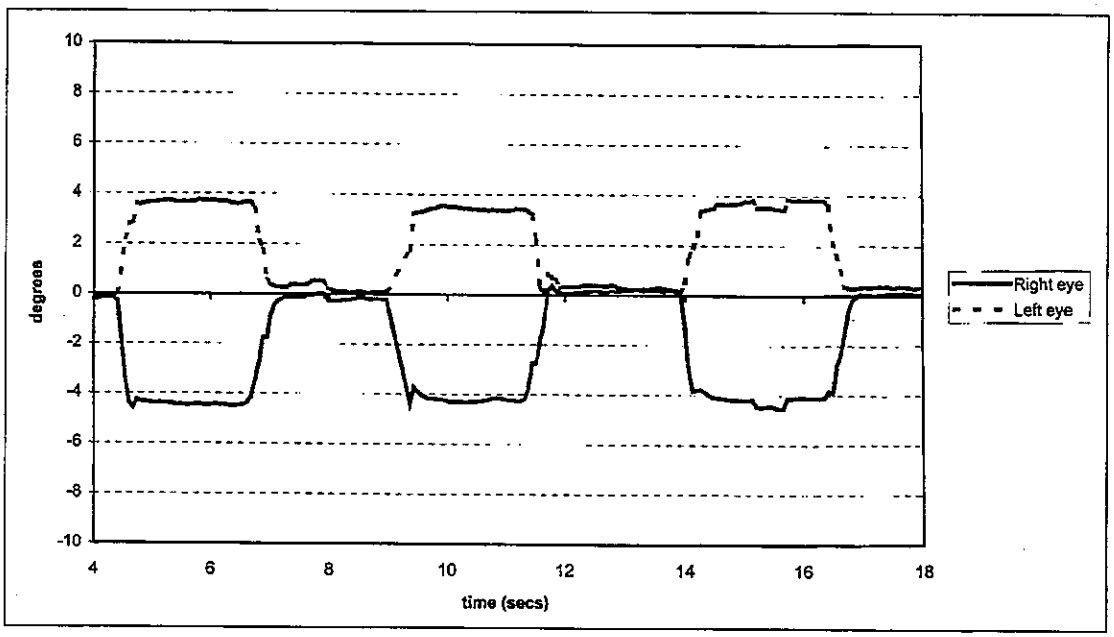

Figure 1. *Response of each eye to a 10° vergence stimulus. This represents a normal response. The traces separate during convergence movements for near fixation and come together for distance fixation. The small failure to diverge fully is within normal limits.*

Figure 2 shows a response to a 5° stimulus. The left eye shows a deficient and inconsistent response to both convergence and divergence. The right eye seems to be the 'fixing' eye but the response is slow and not always accurate. This pattern is probably familiar to most clinicians.

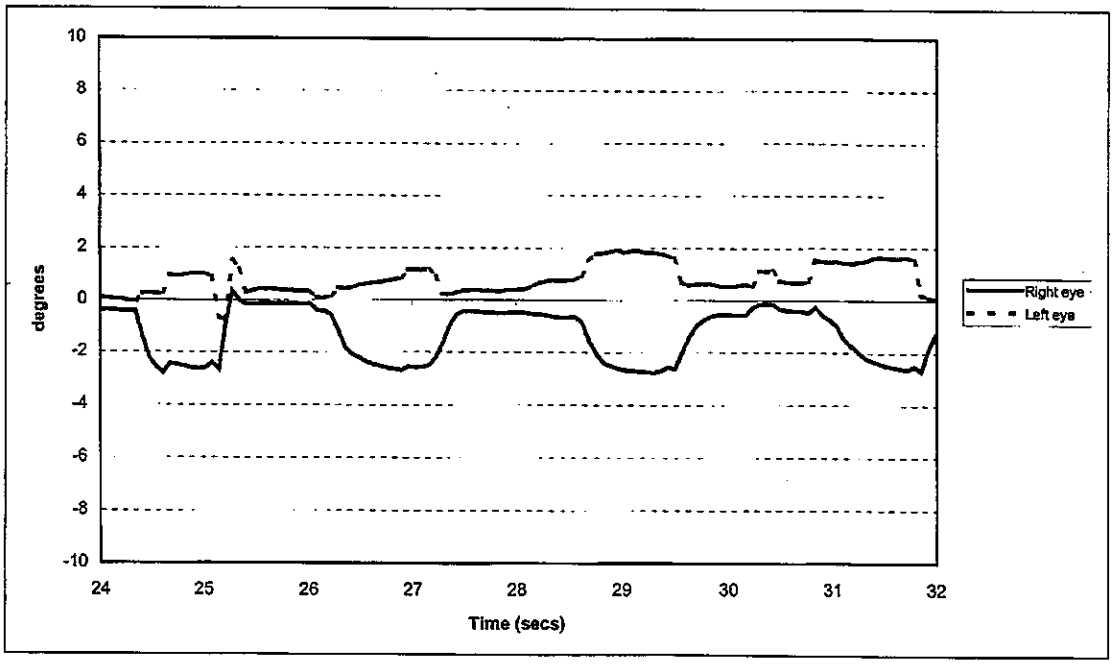

Figure 2. *Response of each eye to a 5° vergence stimulus. The left eye shows reduced, and variable convergence responses, the right eye shows slow but mostly accurate convergence responses. There is a reduced divergence response in each eye.*

Figure 3, again a response to a 5° stimulus, shows one near normal movement, otherwise there is a conjugate response, with the right eye adducting and the left eye abducting for near fixation, and the reverse for far fixation. Again, this response, whilst being abnormal, is likely to be familiar to clinicians.

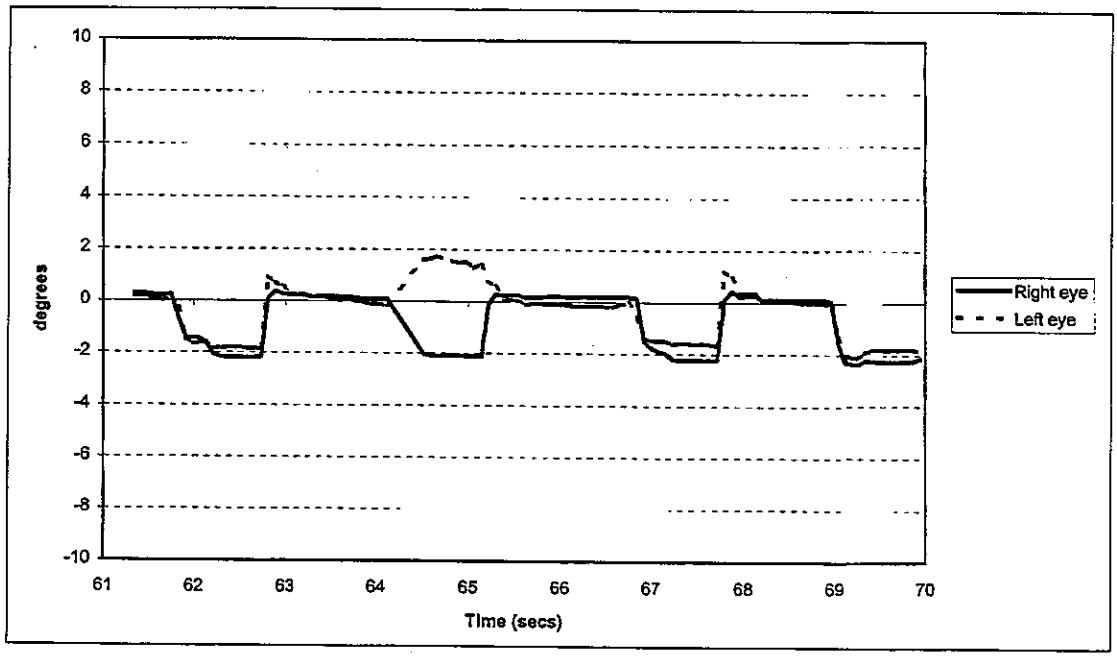

Figure 3. *Response of each eye to a 5° vergence stimulus. On one occasion there is an attempt of the left eye to converge. Otherwise there is an equal conjugate response, with the right eye fixing.*

Figure 4, a response to â 10° stimulus, shows relatively normal fixation of the right eye, with a much smaller conjugate movement in the left eye. In this case the right eye was making a full adducting movement to fixate for near, whilst the left eye was making a consistent, but much smaller abducting movement.

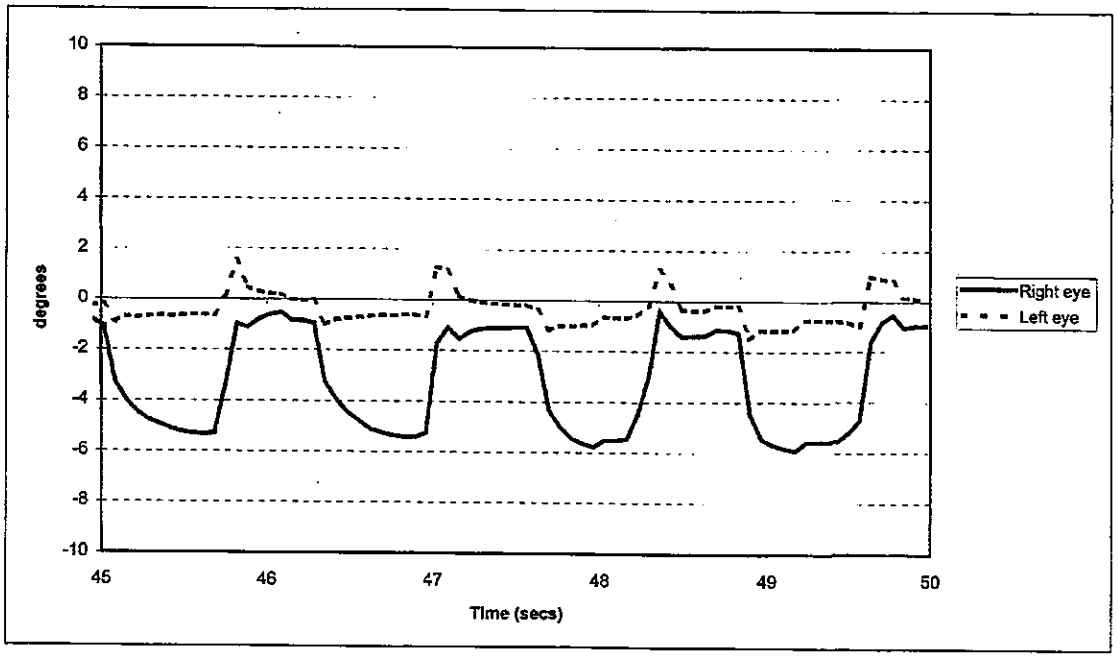

Figure 4. *Response of each eye to a 10° vergence stimulus. There is an unequal conjugate movement of the eyes, with the right eye fixing, and the left eye making a much smaller conjugate movement.*

Figure 5, a response to a 15° stimulus, shows consistent, but very asymmetrical vergence. The right eye is making an accurate movement, whilst the left eye is making a consistent but hypometric vergence movement.

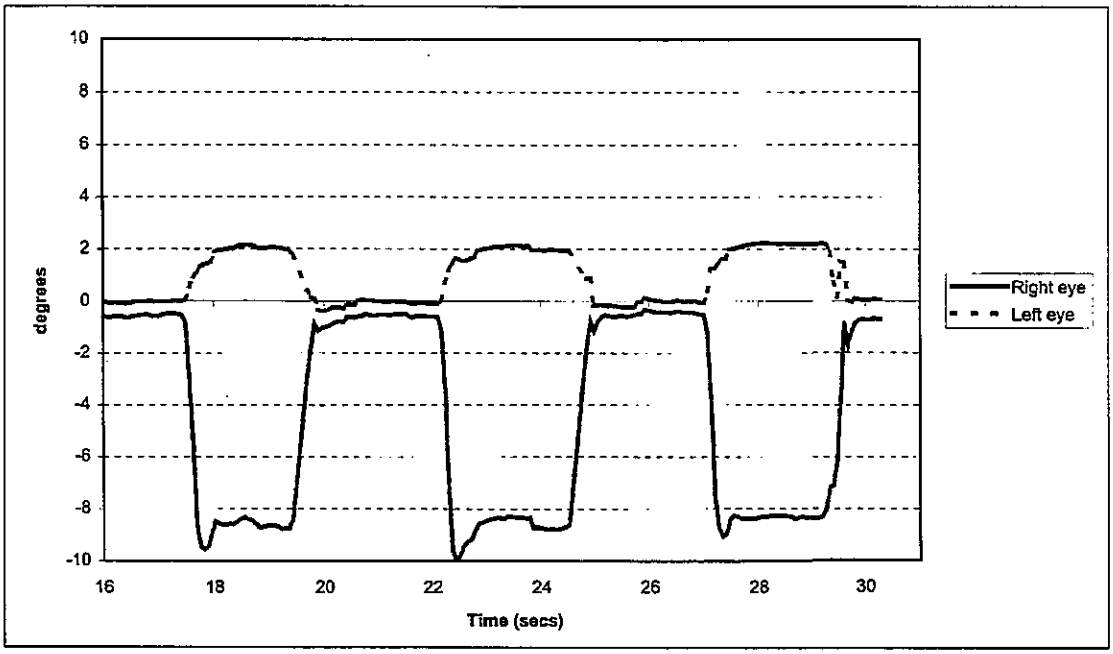

Figure 5. *Response of each eye to a 15° vergence stimulus. There is an unequal vergence movement. The right eye converges fully, the left eye makes a much smaller vergence movement. There is insufficient divergence of the eyes.*

Figure 6, again a response to a 15° stimulus, shows normal convergence of the right eye, however the left eye remains fixing for distance. This seems to be a very unusual movement to a target on the midline, not normally observed in orthoptic practice.

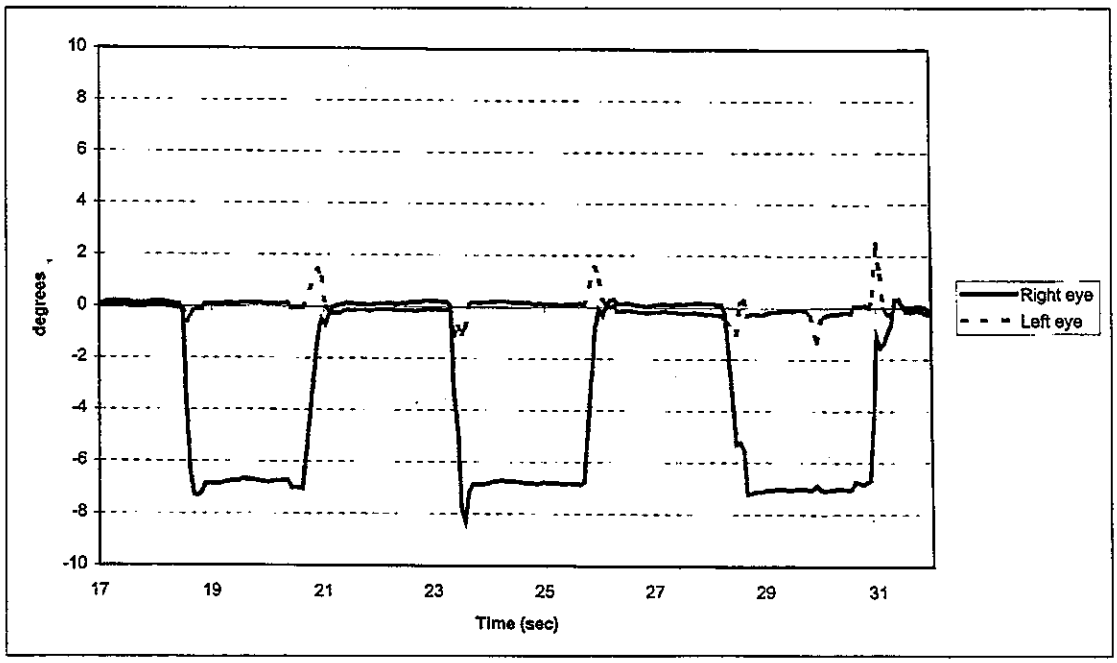

Figure 6. *Response of each eye to a 15° vergence stimulus. The right eye makes an accurate convergence and divergence movement, however the left eye does not move, but remains fixing for distance.*

DISCUSSION

Although SR had moderate exophoria, she was not aware of it, and it appeared to be fully compensated. She showed several abnormal vergence and conjugate movements, some of which did not obey Hering's Law, yet she did not notice diplopia, and had no history of symptoms, despite undertaking a lot of close work. Although she obviously had some sensory mechanisms to cope with these abnormal eye movements, they must have varied with each type of response, and did not result in ongoing reduced stereoacuity or decompensation of her heterophoria.

Similar abnormal vergence movements in normal subjects have been reported by others. Van Leeuwen et al[1] reported on the eye movements of ten normal subjects and five subjects with convergence insufficiency. They differentiated their subjects into two groups, 'vergence responders' who made correct vergence shifts, sometimes associated with small saccades, and 'saccadic responders' who fixated the far targets with both eyes, but made a conjugate movement to the near target, fixating with only one eye. Of the six saccadic responders in their study, three were from the "normal" group and three were from the CI group. They comment that *"binocular motor control is not as binocular as assumed in subjects without complaints."*

Collewijn et al[2] made an incidental observation from a study of the dynamics of version and vergence eye movements in a group of normal subjects. Some were observed to make 'ambiguous' vergence movements, *"some vergence shifts had only half the required size: one eye shifted to the nearer or further target, whilst the other eye continued to fixate the (first) target".*

Malinov et al[3] in a study on eye movements towards targets within arm's reach reported that subjects 'under-verged' by 25-35% during these tasks. Steinman[4], reporting a similar experiment from the same laboratory commented that *"vergence was set and held such that the lines-of sight intersected in space well beyond arms' reach (80 - 110 cm) despite the fact that all targets were well within arms' reach (nearer than 50 cm)".*

These observations question the cause of symptoms in the patients we see with decompensating heterophoria or convergence insufficiency. Van Leeuwen et al[1] comment that the symptomatic subjects in their study were those who did not have a strong monocular preference that would allow suppression to occur. They report that none of the convergence insufficiency subjects used one eye consistently for fixation. Certainly SR showed a strong preference for the right eye, however this monocular preference would also appear to be the pattern in many convergence insufficiency patients seen in orthoptic practice. It could be that those people who can make ready sensory adaptations to abnormal vergence movements remain symptom free, those who cannot do so resort to clinically diagnosed suppression or experience the common symptoms of convergence insufficiency or decompensating heterophoria.

It is interesting that although SR noticed diplopia on failure of convergence and base in prism fusional amplitudes, she did not notice it during the eye movement recording sessions. During these sessions pauses in fixation were no longer than two seconds duration. It is possible that there is a normal form of 'vergence suppression' that occurs during and just after a vergence eye movement, similar to 'saccadic suppression' (suppression of vision during a saccade). Manning and Riggs[5] have described a form of visual suppression in normal subjects who were less sensitive to a stimulus when it was presented at the beginning of a 2-3° convergent or divergent eye movement, than when it was presented during steady fixation.

Patients who report diplopia normally describe it as something that persists for a definite period of time, rather than as a brief phenomenon. Although some heterophoric patients notice fleeting diplopia during the cover/uncover test immediately after the cover has been removed, in these cases the eye may have been covered for longer than this hypothesised suppression period. Therefore, as Manning and Riggs[5] suggest, the concept of saccadic suppression should be broadened to include visual suppression that also accompanies non saccadic eye movements.

CONCLUSIONS

Abnormal patterns of binocular fixation, without diplopia, can occur in subjects with normal binocular vision and in those with well-controlled heterophoria. It is proposed that this phenomenon may be a consequence of visual suppression occurring during, and immediately following a binocular eye movement, similar to that which occurs during a saccadic eye movement.

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