REFRACTIVE AMBLYOPIA AND THE VEP

JM was initially evaluated in my office on April 28, 2006. At that time he was four and one half years old, having recently been diagnosed as having amblyopia for which he was given the following Rx:

OD: +2.00 sphere
OS: +5.25 sphere

Entering visual acuities were:

OD: 20/25 with or without Rx
OS: 20/200 without Rx and 20/40-2 with Rx

JM complained of headaches when being patched, and exhibiting fatigue. He came in wearing his glasses, but frequently peering above them. His binocular profile showed exophoria with random dot stereopsis present. His hyperactivity made it difficult for JM to sustain fixation at near, and accommodate accurately.

Parents of a child with hyperopic anisometropic amblyopia come to us with the desire to not only help their child improve visual function through the Rx, but to ultimately reduce or eliminate the Rx without sacrificing visual function. Seeing the strong lens power required for the amblyopic eye reminds them that this is a relatively “weak” or “lazy” eye.

Upon completing office-based optometric vision therapy, visual acuity through JM’s spectacle Rx improved to 20/25 OS. More compelling, JM’s unaided VA OS was now the same as his aided VA. The conventional explanation for this is that JM had learned to accommodate more precisely through his left eye as a result of vision therapy, as it is common for patients with amblyopia to have substandard accommodation.

Pursuing a goal of lessening the power difference in Rx between the two eyes, we reduced JM’s Rx to +4.50 OS from +5.25, and subsequent visits showed that he was able to hold steady at 20/25 with our without Rx OS. We wondered if we could be more aggressive in reducing the Rx without risking regression. It was obvious that even though JM could identify Snellen letters well with his left eye, he needed to work harder to resolve the letters than with the right eye, and was still subject to some crowding.

At the time of the initial evaluation we did not have the Diopsys VEP system in our office. We therefore have no data that served as a baseline prior to vision therapy. When JM came in with his mother for their last visit, I advised her that we now had a more sensitive baseline measure available to establish, which would help guide us in monitoring:

a) if there has been regression in visual function and
b) when and if it is appropriate to reduce JM’s spectacle Rx further.

JM’s mother was very interested in us conducting the test, which we did, and noted the following results. We recorded JM’s VEP under the same conditions, wearing his habitual Rx, with three different check sizes, 16, 30 and 60. The largest check size is the smallest number, since it counts the number of black and white checks that occupy the screen at the 1 meter viewing distance. We selected these check sizes because they were reasonable at maintaining interest for a 6 year-old active child. Any size smaller would not have held JM’s attention. Contrast was held constant at 85% and test time for each condition was a 20 second viewing time. We had excellent cooperation from JM, who is now 6 years old.

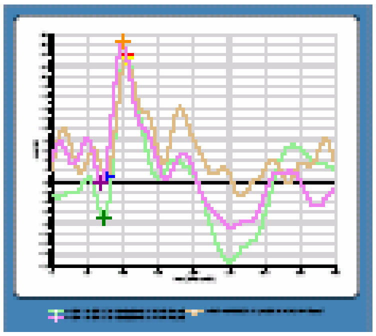
We have superimposed the results from OD, OS, and OU for comparison, and there are several significant results to note from the following graphs and tables. For reference, the graphs correspond to green for OD, magenta for OS, and brown for OU. We’ll examine three characteristics of the VEP:

- overall waveform, latency, and amplitude

Traditionally, the most reliable variable clinically is the latency for the
P100 value, or the rise of the waveform to its peak around the 100 millisecond (ms) time frame on the scale. Even though the amplitude of the wave (distance from trough to peak) and the waveform itself can be more variable, some insights can be gained by their inspection as well.

Figure 1 shows that, for the largest check size we used (16), the waveform appearance is similar for all three conditions, OD, OS and OU.

FIGURE 1



The corresponding values for the waveforms generated are as follows:

	T=20-P=16-OD-85%-C- 6/16/08 10:19:30 AM Filtered	T=20-P=16-OS-85%-C- 6/16/08 10:18:43 AM Filtered	T=20-P=16-OU-85%-C- 6/16/08 10:15:44 AM Filtered
Left Cursor	73.33 ms	76.66 ms	70.00 ms
	-6.9 uV	0.94 uV	-0.4 uV
Right Cursor	105.0 ms	105.0 ms	100.0 ms
	23.9 uV	23.5 uV	26.3 uV
Delta	31.66 ms	28.33 ms	30.00 ms
	30.9 uV	22.5 uV	26.8 uV
Eye	OD	OS	OU
CheckSize	16	16	16
Test Time	20	20	20
Contrast	85	85	85
Pattern	Checkerboard	Checkerboard	Checkerboard
Binasal	N	N	N
Filtered	Y	Y	Y

The latency values seen at point P1, or the values marked for the Right Cursor in the table, are:

OD: 105.0 ms
OS: 105.0 ms
OU: 100.0 ms

This shows that transmission time for the signal to be processed in the occipital lobe, more specifically in V1 of the visual cortex, is identical for the right and left eyes independently, and that there is summation in speed of transmission when both eyes are viewing together. The normal summation is around 10% and this was 5%. But the key is that when there is clinically significant suppression or interference from through the amblyopic eye under OU conditions, not only might summation be absent, but the latency might actually slow down slightly under OU conditions.

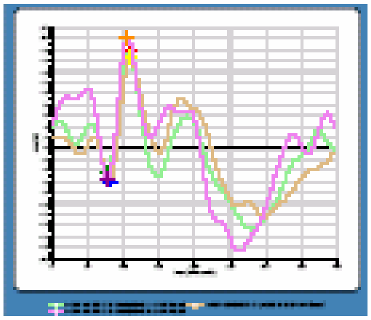
Although not typically as reliable a finding, when we look at the amplitude or height of the wave in millivolts (uV), from N1 to P1, or left cursor to right cursor (delta), we'll note the following delta values in the table:

OD: 30.9 uV
OS: 22.5 uV
OU: 26.8 uV

So in this instance the amplitude is lower through the amblyopic eye (OS) as compared to the dominant eye (OD), and appears less OU than through the non-amblyopic eye (OD).

Let's look at results for the mid-size checks we used, the 30 check size. Figure 2 shows that the appearance of the waveforms is nearly identical for the OD, OS and OU conditions.

FIGURE 2



The corresponding values to the waveform in Figure 2 are as follows:

	T=20-P=30-OD-85%-C- 6/16/08 10:21:17 AM Filtered	T=20-P=30-OS-85%-C- 6/16/08 10:20:07 AM Filtered	T=20-P=30-OU-85%-C- 6/16/08 10:16:24 AM Filtered
Left Cursor	78.33 ms	81.66 ms	78.33 ms
	-4.1 uV	-6.0 uV	-5.7 uV
Right Cursor	108.3 ms	110.0 ms	106.6 ms
	17.9 uV	16.4 uV	20.1 uV
Delta	30.00 ms	28.33 ms	28.33 ms
	22.1 uV	22.4 uV	25.8 uV
Eye	OD	OS	OU
CheckSize	30	30	30
Test Time	20	20	20
Contrast	85	85	85
Pattern	Checkerboard	Checkerboard	Checkerboard
Binocal	N	N	N

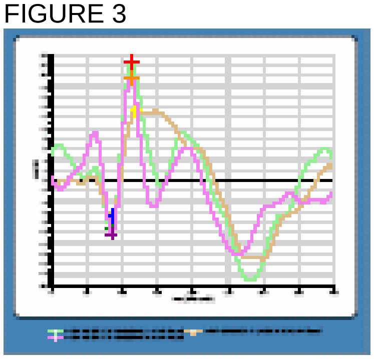
The latency values seen at point P1, the values marked for the Right Cursor in the table, are:

OD: 108.3 ms
OS: 110.0 ms
OU: 106.0 ms

As compared to the larger check sizes, P100 shows slightly reduced latency OS relative to OD for these check sizes. However, as with the larger check sizes, there is still a small summation rather than inhibition effect for the OU condition.
The amplitude or delta value at this check size is the same for the OU condition as it is for the OS condition, both less than the OD condition.

Lastly, we'll look at results for the smallest check size (60) of the three presentations.

FIGURE 3



As can be seen in Figure 3, the waveform of the amblyopic eye is now significantly different from both the OD dominant eye recording, and the OU recording immediately around the P100 value.

The corresponding values for Figure 3 are as follows:

	T=20-P=60-OD-85%-C- 6/16/08 10:21:47 AM Filtered	T=20-P=60-OS-85%-C- 6/16/08 10:20:43 AM Filtered	T=20-P=60-OU-85%-C- 6/16/08 10:16:58 AM Filtered
Left Cursor	85.00 ms	85.00 ms	85.00 ms
	-9.1 uV	-6.8 uV	-10. uV
Right Cursor	113.3 ms	120.0 ms	113.3 ms
	22.4 uV	13.2 uV	19.7 uV
Delta	28.33 ms	35.00 ms	28.33 ms
	31.6 uV	20.1 uV	29.9 uV
Eye	OD	OS	OU
CheckSize	60	60	60
Test Time	20	20	20
Contrast	85	85	85
Pattern	Checkerboard	Checkerboard	Checkerboard
Binasal	N	N	N
Filtered	Y	Y	Y

The latency values seen at point P100, the values marked for the Right Cursor in the table, are:

OD: 113.3 ms
OS: 120.0 ms
OU: 113.3 ms

For these, the smallest check sizes presented, P100 now shows significantly reduced latency for OS as compared to OD. There is no longer a summation effect on OU recording, as the latency OU is equal to the latency for OD, the dominant eye. The amplitude or delta value at this check size is the same for the OU condition as it is for the OD condition, both greater than the OD condition.

We can summarize the three sets of data as follows:

1. As the check size gets progressively smaller, there is a point at which cortically the pattern is being processed solely by the non-amblyopic eye, the electrophysiological correlate of central suppression in the presence of normal binocular motor alignment.
2. The latency of the P100 is the most reliable index, both for the differences between OD and OS, and for binocular summation.
3. The waveform appearance generally supported the observations of #1 above.
4. The amplitude of the P100 wave was not a reliable index of amblyopic function in this series.

Given the baseline JM was able to provide, we now have data that will assist us in the future in monitoring:

a) if his binocular cortical summation pattern remains stable as we follow JM post-therapeutically
b) if reducing the power of the amblyopic Rx helps or hinders pattern vision
c) if reducing the power of the amblyopic Rx helps or hinders binocular summation.

Lastly, we note that the patterns used in this series were filtered. The Diopsys system gives the clinician the option of looking at graphs filtering out noise, or at unfiltered data. For young children we prefer to use the filtered data to minimize noise. We have also developed a protocol where we repeat each condition twice. In this instance we did each of the three check sizes twice for the OD, OS and OU conditions respectively. We used the data giving the better waveform for each of the conditions. What we have learned, particularly with young children, is that there can be significant variability in the data. Therefore, a clinician should never assume that changing one variable, such as check size or the change of lens Rx had a specific effect, when recording only once for each condition.

We use an analogy to intraocular pressures. It is axiomatic, when measuring IOPs, that if one reading is high and a second reading is low, the valid IOP is the lowest measure, since several factors such as squeezing in apprehension can falsely elevate IOP. Owing to attention factors and movement of the patient, particularly with young children, the quality and transmission properties of the VEP can look poor on any given recording. That is why it is crucial to do multiple recordings under identical conditions. Whichever results look best of repeated measures becomes the graph and data to be used for cross-comparisons when a change is made, be it VT, binasal occlusion, Rx power change, and so forth.