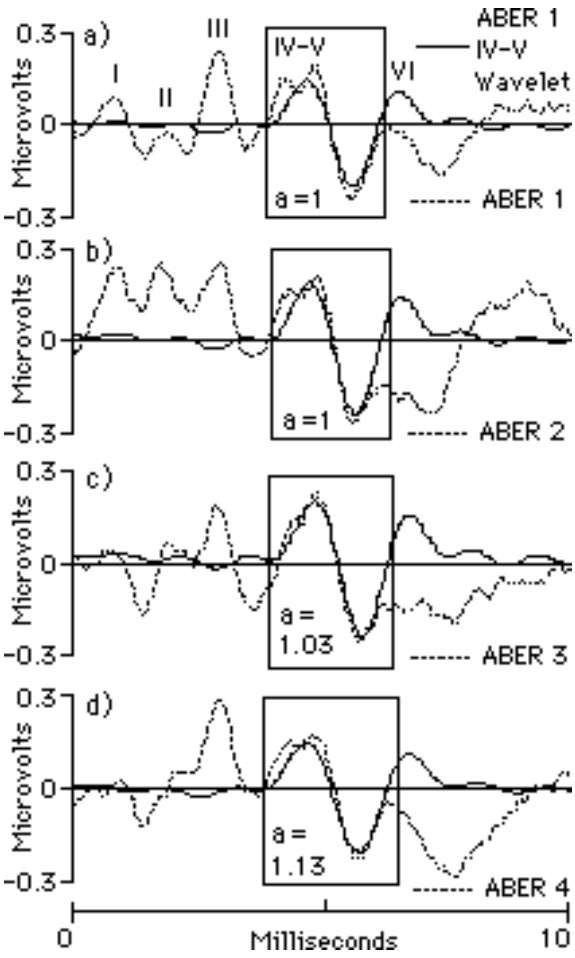

Figure 1. ABERs of 4 patients (80 dB NHL clicks). Scaling coefficient "a" indicates proportionate scaling relative to ABER 1.

audiometric threshold evaluation algorithms. Customized ABER wavelets can be incorporated into software to improve hearing assessment in the universal newborn auditory screening programs now being implemented in the United States in response to the National Institutes of Health Consensus Panel's 1993 recommendations. Generally, matched wavelets will benefit the study of auditory system function and hearing loss evaluation in infants and adults by improving the characterization of ABER responses.

2.2 Matched P300-ERP Wavelet

Figure 2b shows a Meyer wavelet matched to the group-averaged cognitive Pz P300-ERP. The P300-ERP wavelet tracks the dominant low frequency P300 component well.

2.2.1 Comparative ERP Wavelet Decompositions

Figure 2c shows multiresolution representations (MRR) associated with typical 5-level MRA wavelet decompositions of the averaged Pz P300-ERP using the matched P300-ERP wavelet, Haar wavelet, and Daubechies D4 wavelet. MRRs are sequences of successively lower resolutions of the ERP obtained by removing successive levels of high frequency detail (detail functions) by passing the ERP through wavelet based filters at successively larger dyadic scales. Clearly, the Haar and the Daubechies D4 MRRs preserve the physiologically unnatural shape properties of their wavelet basis functions up to the highest level of resolution in their MRRs.

A general shape mismatch between the ERP and the wavelet basis functions used to analyze it will tend to delocalize waveform details at specific scales of activity, dispersing energy more widely in the time-scale plane than matched wavelets. Consequently, naturally band-limited ERP components will be more concisely partitioned by a matched, physiologically natural wavelet.

The dispersive effect of shape mismatch is evident in Figure 2c. For the matched Meyer P300-ERP wavelet, the match between the MRR and the high resolution ERP is essentially complete at the level 4 resolution for the P300 component. The P1-N1-P2-N2 component complex is absent at the level 4 resolution, but appears essentially complete at the level 3 resolution, just one dyadic scale step more. This shows a neat separation into distinct, localized scales of the information associated with the P300 component and the P1-N1-P2-N2 complex, respectively. By contrast, the Haar and Daubechies MRRs tend to confound and misrepresent the P300 and the P1-N1-P2-N2 complex over several different scales.

2.2.2 Localization of Clinically Relevant Group Differences

To demonstrate that wavelet analyses can localize functionally meaningful effects in ERP data sets, we computed a 5-level MRA on each of 306 ERPs obtained in a visual odd-ball paradigm [12]. Subjects (25 controls and 26 alcoholics) produced ERPs at left and right hemisphere parietal sites (P3 and P4) in response to a rare visual target (an "X"), rare novel shapes, and a frequent standard shape (a square). MRA coefficients for these ERPs were analyzed in three 4-way repeated measures analyses of variance (ANOVA), one for the level 5 low resolution signal and one each for the levels 5 and 4 detail functions (factorial design: Group X Hemisphere X Stimulus Type X Coefficient Sequence). These three coefficient sets nominally reflect ERP frequencies in the .02-4 Hz (delta), 4-8 Hz (theta), and 8-16 Hz (alpha) ranges, respectively. The level 5 detail function contributed energy maximally to the P300, while the level 4 detail function primarily determined the P1-N1-P2-N2 complex.

The level 5 low resolution ANOVA produced no significant group effects. A significant Group X Coefficient Sequence interaction was found for each detail function: Level 5, $F(13,637)= 2.42$, $p<.0035$; Level 4, $F(29,1421)= 2.38$, $p<.0001$. Figure 3 shows the sources of these interactions graphically. The bar plots show the numerical difference between the control and alcoholic groups in the average magnitudes (absolute values) of their wavelet coefficients at each translation (time step). The superimposed grand average ERP shows that the significant group differences at level 5 (4-8 Hz theta) occurred within the span of the P300, consistent with earlier P300 studies [12], while the significant group differences at Level 4 (8-16 Hz alpha) occured primarily