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TECHNICAL NOTES
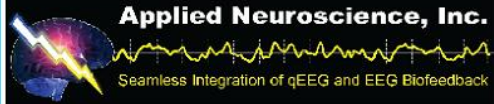
Hjorth Referencing in QEEG

Jay Gunkelman, QEEGT, Editor

Laplacian physics (and mathematics) of passively conducted electric currents is applicable to the analysis of the EEG. To be validly used, the data has to meet two assumptions: (1) Continuity of function; and (2) Differentially measurable at the surface. These assumptions are met by the EEG itself, but not by the measurement of the EEG at discrete electrode sites.

To provide the illusion of a continuous function in qEEG mapping, interpolation techniques are used. These range from simplistic linear approaches to complex calculations. Some commonly included techniques include: spherical and thin plate spline interpolation, spherical harmonic expansion, Taylor series expansions and even simple inverse logarithm functions.

A new solution was proposed for EEG referencing and interpolation in 1980 by Hjorth (American Journal of EEG Technology. 20: 121-132; Hjorth, B.; Source derivation simplifies topographical EEG interpretation).

With the Hjorth referencing technique, each electrode is referenced to the local surrounding electrodes as a weighted average of the poten-

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tials, with the weighting proportional to the reciprocal distance to the center point, normalized to sum to 1. This is a second spatial partial derivative for the two tangential axis, at the point.

A more modern approach when calculating the Hjorth reference is to use the mean ''electrical distance'', rather than the physical distances. This practice allows the calculations to be done strictly based on the recorded voltages.

It is important to realize that the Hjorth montage yields the radial current source density, *not* the voltage, though the units reported are traditionally given in microvolts.

The strength of the technique is the increased resolution of the mapping, with reduced voltage displacements from contaminated references. The increased resolution gives very good localization of any focal findings.

Every montage referencing technique has its unique advantages and weaknesses. The weakness of the Hjorth technique is false localization to the ''edge'' of a regional finding. When all reference electrodes are ''on'' a regional finding, it is not seen. When one falls outside the area, it appears.

Modern qEEG machines allow the user to remontage the data after it has been recorded. The advances in computer hardware computing power gives the user access to powerful resolution enhancing montages using Laplacian mathematics.

This technique is variously called: Hjorth, Laplacian, local average, source derivative and virtual reference depending on the schooling of the qEEG practitioner.

The examples given (Figures 1 through 8) illustrate the strengths and weaknesses of three reference systems (Hjorth, linked ears, and Cz). The comparison of these reference techniques is done showing both raw EEG and maps. ''Mu'' rhythm at C3 is shown in Figures 1 through 6. Elimination of cardioballistic artifact using Hjorth technique is shown in Figures 7 and 8. A previous discussion in Technical Notes (*Journal of Neurotherapy*, Volume 3, Number 3, pages 37-40) illustrates the effect of montaging technique on the appearance of O2 lambda.

FIGURE 1. Mu in Hjorth montage
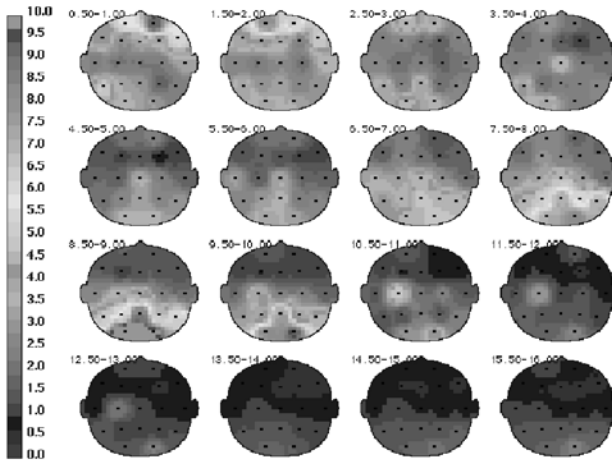

FIGURE 2. Linked ears Mu
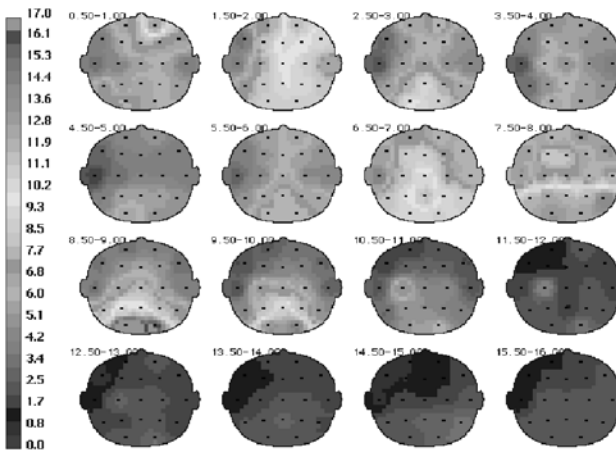
FIGURE 3. Hjorth Mu

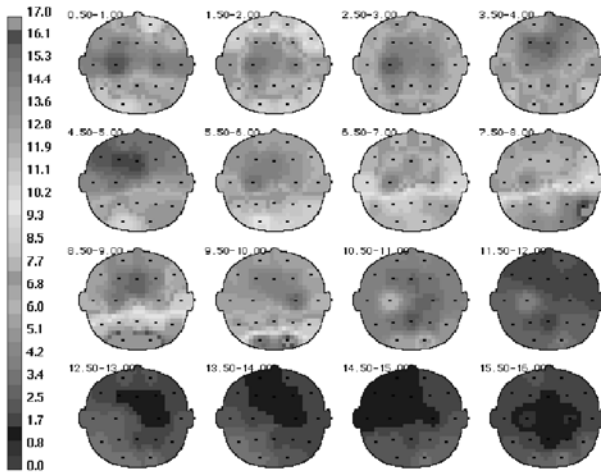FIGURE 4. Linked ear Mu

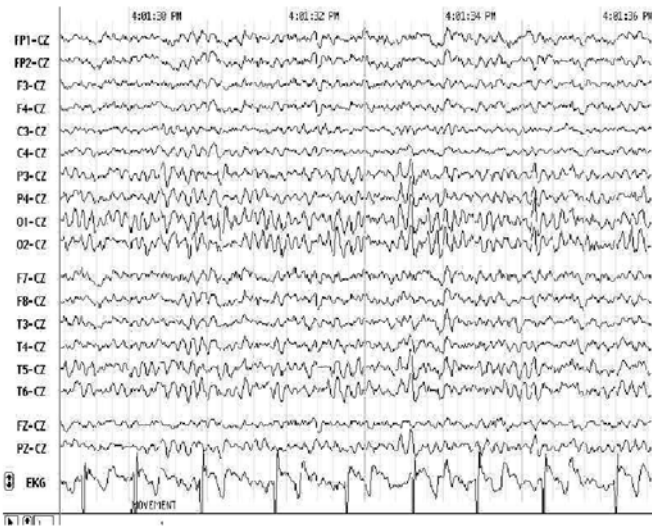FIGURE 5. Cz reference Mu
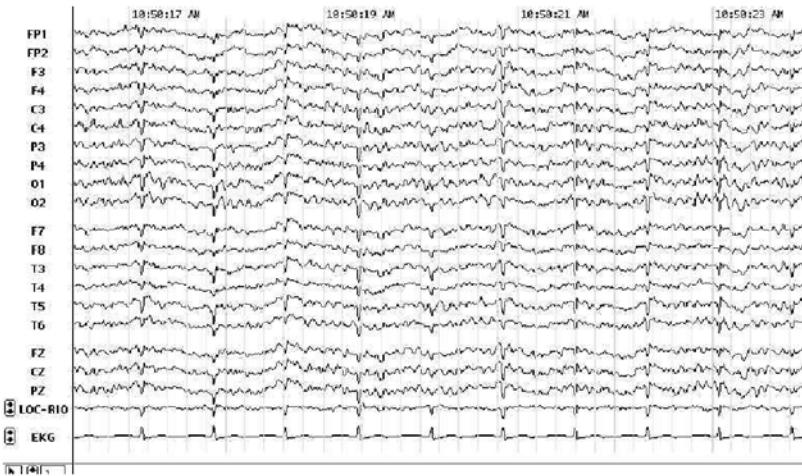

FIGURE 6. Cz reference Mu

FIGURE 7. Linked ear reference with EKG artifact

FIGURE 8. Hjorth referencing of the same data