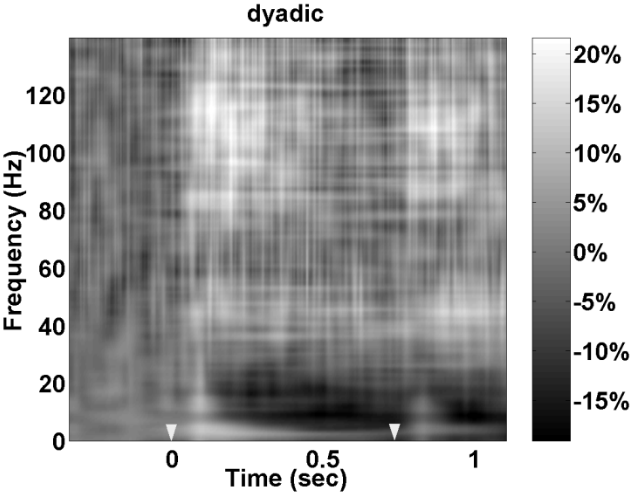

Fig. 4. The dark band at 10–20 Hz is due to power suppression while the bright bands at ∼45 and 80–120 Hz are due to power augmentation. White arrowheads at $t = 0$ and 0.745 s indicate onsets of two speech stimuli ($\mathrm{duration} = 300$-ms).

frequencies near $\mathrm{F_M}/2, \mathrm{F_M}/4$, and $3\mathrm{F_M}/4$ ($\mathrm{F_M} = 331/2$ Hz). *However, the TF plots constructed using both the methods were almost identical* [Figs. 3 and 4]. For quantitative analysis, we divided the TF plots into bins of time 12-ms and frequency 1.3 Hz. The absolute difference in the two dictionaries was less than 3% for more than 90% of the T-F bins. The mean absolute difference was 1.4%. Even at half the sampling frequency, which had the maximum bias in the dyadic case, the mean absolute difference was 1.31%. The power-frequency plot constructed by averaging the TF plot over time differed by less than 1.37% at any time ($\mathrm{avg.\ difference} = 0.37$%). The power-time plot at any given frequency differed by, on average, less than 1%. Hence, the TF plot was essentially unaffected by the frequency bias in dyadic MP.

To explain this we looked at the properties of the atoms in the biased frequencies. We observed a high concentration of small scale $(s \leq 3)$ atoms (76.4% against 15% at unbiased frequencies) in these regions. Small scale values are highly localized in time but widely spread across frequency; as a result there was frequency smoothing due to small s atoms. Hence, despite the large number of atoms there was no *power* concentration in the biased frequencies, thus giving essentially the same results as the stochastic MP.

V. CONCLUSION

We demonstrate the utility of the MP algorithm for spectral analysis of subdural ECoG signals and in particular the high-frequency gamma activity that is best seen in ECoG recordings. We also show that the stochastic and dyadic MP are equally good for constructing TF power plots, but the dyadic MP is computationally much faster than the stochastic MP. TF power plots are unaffected by the frequency bias of the dyadic dictionary.

Other approaches, such as wavelet transforms, have been used to generate TF plots for EEG. However, as we're interested in power changes in a specific frequency band, the wavelets must be carefully chosen to provide maximum frequency resolution in the frequency band of interest, and this requires a prior knowledge of the frequency band where power changes take place. Previous experience with event-related spectral analysis in scalp EEG has demonstrated a significant variability in the frequency bands that are most reactive to cortical activation [9]. Therefore, the MP algorithm provides a valuable exploratory tool to determine the frequencies where power changes take place in association with functional cortical activation.

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REFERENCES

[1] S. Mallat and Z. Zhang, "Matching Pursuit with time-frequency dictionaries," *IEEE Trans. Signal Processing*, vol. 41, pp. 3397–3415, Dec. 1993.
[2] P. J. Durka, D. Ircha, and K. J. Blinowska, "Stochastic time-frequency dictionaries for matching pursuit," *IEEE Trans. Signal Processing*, vol. 49, pp. 507–519, Mar. 2001.
[3] P. J. Durka and K. J. Blinowska, "A unified time-frequency parametrization of EEGs," *IEEE Eng. Med. Biol. Mag.*, pp. 47–53, Sept./Oct. 2001.
[4] P. J. Durka, D. Ircha, C. Neuper, and G. Pfurtscheller, "Time-frequency microstructure of event-related EEG desynchronization and synchronization," *Med. Biol. Eng., Comput.*, vol. 39, no. 3, pp. 315–321, May 2001.
[5] N. E. Crone, D. L. Miglioretti, B. Gordon, and R. P. Lesser, "Functional mapping of human sensorimotor cortex with electrocorticographic spectral analysis. Pt. II: Event-related synchronization in the gamma band," *Brain*, vol. 121, pp. 2301–15, 1998.
[6] N. E. Crone, D. Boatman, B. Gordon, and L. Hao, "Induced electrocorticographic gamma activity during auditory perception," *Clin. Neurophysiol.*, vol. 112, pp. 565–82, 2001.
[7] M. Brosch, E. Budinger, and H. Scheich, "Stimulus-related gamma oscillations in primate auditory cortex," *J. Neurophysiol.*, vol. 87, pp. 2715–2725, 2002.
[8] N. E. Crone, L. Hao, J. Hart Jr., D. Boatman, R. P. Lesser, R. Irizarry, and B. Gordon, "Electrocorticographic gamma activity during word production in spoken and sign language," *Neurology*, vol. 57, no. 11, pp. 2045–53, 2001.
[9] G. Pfurtscheller and F. H. L. da Silva, "Event-related EEG/MEG synchronization and desynchronization: Basic principles," *Clin. Neurophysiol.*, vol. 110, no. 11, pp. 1842–57, Nov. 1999.
[10] Software for Stochastic and Dyadic MP [Online]. Available: http://brain.fuw.edu.pl/durka/software/mp/index.html

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Correction to "Statistical Performance Analysis of Signal Variance-Based Dipole Models for MEG/EEG Source Localization and Detection"

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In [1, Sec. III-F] we derived several expressions for the probability that the goodness of fit at some location exceeds the goodness of fit at the true source location. In the case of a constant dipole, this probability is shown to be equivalent to the probability that the condition given in [1, eq. (72)] is true, which is the probability that one weighted sum of two Chi-squared random variables, denoted C_1, is larger than

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another weighted sum of Chi-squared random variables, denoted C_2. It is incorrectly stated in [1] that a weighted sum of Chi-squared random variables is also a Chi-squared random variable. This is only true if the weights are equal, or one of them is zero.

Correct calculation of this quantity may be performed by considering the probability that $C_1/C_2 > 1$ using the expression for the cumulative distribution function for a ratio of weighted sums of Chi-squared random variables derived by Provost and Rudiuk [2]. The same approach may be used to calculate this quantity for the variable dipole moment orientation model.

We also note that Dogandzic and Nehorai [3] derive a similar class of test statistics for detecting the presence of a dipolar source using the generalized likelihood ratio test.

REFERENCES

[1] A. Rodriguez-Rivera, B. D. Van Veen, and R. T. Wakai, "Statistical performance analysis of signal variance-based dipole models for MEG/EEG source localization and detection," *IEEE Trans. Biomed. Eng.*, vol. 50, pp. 137–149, Feb. 2003.

[2] S. B. Provost and E. M. Rudiuk, "The exact distribution function of the ratio of two quadratic forms in noncentral normal variables," *Metron*, vol. L, no. 1–2, pp. 33–58, 1992.

[3] A. Dogandzic and A. Nehorai, "Detecting a dipole source by MEG/EEG and generalized likelihood ratio tests," in *Proc. 30th Asilomar Conf. Signals, Systems, and Computers*, vol. 2, 1996, pp. 1196–1200.