Improved Recordings of the Optical Intrinsic Signals in the Neonatal Rat Barrel Cortex

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Abstract

© 2016, Springer Science+Business Media New York.Optical imaging of intrinsic signals (OIS) is widely used for the functional cortical mapping in vivo. Recently, OIS is also implemented for the functional mapping in the neonatal rat barrel cortex. However, the OIS is characterized by relatively low signal to noise ratio (SNR). Here, we determined parameters for post hoc data analysis that allowed improving OIS mapping and analysis in the developing rat barrel cortex in vivo. We found that application of spatial Gaussian filtering with sigma of 1 px increases the OIS SNR almost twofold. Additional light correction and low-pass temporal filtering with 1 s window size resulted in further improvement of the OIS SNR. Thus, the proposed digital filtering can substantially improve quality of the OIS recordings in the developing somatosensory cortex.

Keywords

Barrel cortex, Development, Functional imaging, Intrinsic signal, Somatosensory cortex

References

[1] Grinvald, A., Lieke, E., Frostig, R. D., Gilbert, C. D., Wiesel, T. N. (1986). Functional architecture of cortex revealed by optical imaging of intrinsic signals. Nature, 324, 361–364.

[2] Bonhoeffer, T., & Grinvald, A. (1991). Iso-orientation domains in cat visual cortex are arranged in pinwheel-like patterns. Nature, 353, 429–431.

[3] Rubin, B. D., & Katz, L. C. (1999). Optical imaging of odorant representations in the mammalian olfactory bulb. Neuron, 23, 499–511.

[4] Bakin, J. S., Kwon, M. C., Masino, S. A., Weinberger, N. M., Frostig, R. D. (1996). Suprathreshold auditory cortex activation visualized by intrinsic signal optical imaging. Cerebral Cortex, 6, 120–130.

[5] Sirovich, L., Everson, R., Kaplan, E., Knight, B. W., O'Brien, E., Orbach, D. (1996). Modeling the functional organization of the visual cortex. Physical D, 96, 355–366.

[6] Everson, R. M., Prashanth, A. K., Gabbay, M., Knight, B. W., Sirovich, L., Kaplan, E. (1998). Representation of spatial frequency and orientation in the visual cortex. Proceedings of the National Academy of Sciences of the United States of America, 95, 8334–8338.

[7] Gabbay, M., Brennan, C., Kaplan, E., Sirovich, L. (2000). A principal components-based method for the detection of neuronal activity maps: application to optical imaging. NeuroImage, 11, 313–325.

[8] Mahmoudzadeh, M., Dehaene-Lambertz, G., Fournier, M., Kongolo, G., Goudjil, S., Dubois, J., et al. (2013). Syllabic discrimination in premature human infants prior to complete formation of cortical layers. Proceedings of the National Academy of Sciences of the United States of America, 110, 4846–4851.

[9] Minlebaev, M., Colonnese, M., Tsintsadze, T., Sirota, A., Khazipov, R. (2011). Early gamma oscillations synchronize developing thalamus and cortex. Science, 334, 226–229.

[10] Khazipov, R., Zaynutdinova, D., Ogievetsky, E., Valeeva, G., Mitrukhina, O., Manent, J. B., et al. (2015). Atlas of the postnatal rat brain in stereotaxic coordinates. Frontiers neuroanatomy, 9, 161.

[11] Mitrukhina, O., Suchkov, D., Khazipov, R., Minlebaev, M. (2014). Imprecise whisker map in the neonatal rat barrel cortex. Cerebral Cortex, 25(10), 3458–3467.

[12] Chen-Bee, C. H., Polley, D. B., Brett-Green, B., Prakash, N., Kwon, M. C., Frostig, R. D. (2000). Visualizing and quantifying evoked cortical activity assessed with intrinsic signal imaging. Journal of Neuroscience Methods, 97, 157–173.

[13] O'Farrell, A. M., Rex, D. E., Muthialu, A., Pouratian, N., Wong, G. K., Cannestra, A. F., et al. (2000). Characterization of optical intrinsic signals and blood volume during cortical spreading depression. Neuroreport, 11, 2121–2125.

[14] Grinvald, A., Frostig, R. D., Lieke, E., Hildesheim, R. (1988). Optical imaging of neuronal activity. Physiological Reviews, 68, 1285–1366.

[15] Wadhwa, N., Rubinstein, M., Durand, F., Freeman, W. T. (2013). Phase-based video motion processing. ACM Transactions on Graphics, 32(4), 80.