References

- Aamodt, SM., Nordeen, EJ. and Nordeen KW. Blockade of NMDA receptors during song model exposure impairs song development in juvenile zebra finches. *Neurobiology of Learning and Memory*. 65 (1), 91-98 (1996).
- Arnold, AP, Nottebohm, F. and Pfaff, DW. Hormone concentrating cells in vocal control and other areas of the brain of the zebra finch. J. Comp. Neurology. 301, 245-272 (1976).
- Basham, ME., Nordeen, EJ. and Nordeen, KW. Blockade of NMDA receptors in the anterior forebrain impairs sensory acquisition in the zebra finch (Poephila guttata). *Neurobiology of Learning and Memory*. 66 (3), 295-304 (1996).
- Benton, S., Nelson, DA., Marler, P. and DeVoogd, TJ. Anterior forebrain pathway is needed for stable song expression in adult white-crowned sparrows. *Behavioral Brain Research*. 96, 135-150 (1998).
- Bell, CC. An efference copy which is modified by reafferent input. *Science*. 214, 450-453 (1981).
- Bell, CC. Properties of a modifiable efference copy in an electric fish. J. Neurophysiology. 47 (6), 1043-1056 (1982).
- Bialek W., Rieke F., vanSteveninck RRD. and Warland, D. Reading a neural code. Science. 252 (5014), 1854-1857 (1991).
- Boettiger, CA. and Doupe, AJ. Intrinsic and thalamic excitatory inputs onto songbird LMAN neurons differ in their pharmacological and temporal properties. *J. Neurophysiology*. 76, 2615-2628 (1998).
- Bottjer, SW. and Arnold, AP. The role of feedback from the vocal organ.1. Maintenance of stereotypical vocalizations by adult zebra finches. J. Neuroscience. 4 (9), 2387-2396 (1984).
- Bottjer, SW., Halserna, KA., Brown, SA. and Miesner, EA. Axonal connections of a forebrain nucleus involved with vocal learning in zebra finches. J. Comp. Neurology. 297, 312-326 (1989).

- Bottjer, SW., Miesner, EA. and Arnold, AP. Forebrain lesions disrupt development but not maintenance of song in passerine birds. *Science* 224 (4651), 901-903 (1984).
- Bradley, E. An Introduction to the Bootstrap (Chapman and Hall, New York, 1993).
- Brainard, MS. and Doupe, AJ. Interruption of a basal ganglia-forebrain circuit prevents plasticity of learned vocalizations. *Nature*. 404 (6779), 762-766 (2000a).
- Brainard, MS. and Doupe, AJ. Auditory feedback in learning and maintenance of vocal behavior. *Nature Reviews Neuroscience*. 1 (1), 31-40 (2000b).
- Braun, V. Golay sequences for identification of linear systems with weak nonlinear distortion. *IEE Proc.-Sci. Meas. Technol.* 145 (3), 123-128 (1998).
- Bridgeman, B. A review of the role of efference copy in sensory and oculomotor control systems. *Annals of Biomedical. Engineering.* 23, 409-422 (1995).
- Carr, C. Locating an error correction signal for adult birdsong. *Nature Neuroscience*. 3 (5), 419-421 (2000).
- Casacuberta, F., Vidal, E. and Rulot, H. On the metric properties of dynamic time warping. *IEEE Trans. Acoust. Speech.* 35 (11), 1631-1633 (1987).
- Chi, ZY. and Margoliash, D. Temporal precision and temporal drift in brain and behavior of zebra finch song. *Neuron*. 32 (5), 899-910 (2001).
- Cover, TM. and Thomas, JA. *Elements of Information Theory* (John Wiley and Sons, New York, 1991).
- Dave, AS. and Margoliash, D. Song replay during sleep and the computational rules for sensorimotor vocal learning. *Science*. 290, 812-816 (2000).
- Doupe, AJ. Song- and order-selective neurons in the songbird anterior forebrain and their emergence during vocal development. *J. Neuroscience*. 17 (3), 1147-1167 (1997).
- Doupe, AJ. and Konishi, M. Song-selective auditory circuits in the vocal control-system of the zebra finch. *PNAS*. 88 (24), 11339-11343 (1991).
- Fee, MS. and Leonardo, A. Miniature motorized microdrive and commutator system for chronic neural recording in small animals. J. Neuroscience Methods. 112, 83-94 (2001).
- Fee, MS., Shraiman, B., Pesaran, B. and Mitra, PP. The role of nonlinear dynamics of the syrinx in birdsong production. *Nature*. 395, 67-71 (1998).

- Feller, W. An Introduction to Probability Theory and its Applications (John Wiley and Sons, New York, 1968)
- Foster, S. Impulse response measurement using Golay codes. *IEEE international conference* on acoustics, speech and signal processing. 2, 929-932 (1986).
- Georgopoulos, AP., Schwartz, AB. and Kettner, RE. Neuronal population coding of movement direction. *Science* 233 (4771), 1416-1419 (1986).
- Georgopoulos, AP., Pellizzer, G., Poliakov, AV. and Schieber, MH. Neural coding of finger and wrist movements. *J. Computational Neuroscience*. 6 (3), 279-288 (1999).
- Golay, MJE. Complementary series. IRE Trans. Information Theory. II-7, 82-87 (1961).
- Goller, F. and Suthers, RA. Implications for lateralization of bird song from unilateral gating of bilateral motor patterns. *Nature*. 373 (6509), 63-66 (1995).
- Goller, F. and Suthers, RA. Role of syringeal muscles in controlling the phonology of bird song. *J. Neurophysiology*. 76 (1), 287-300 (1996).
- Hahnloser, RHR., Kozhevnikov, AA. and Fee, MS. An explicit representation of time underlies the generation of neural sequences in a songbird. *Submitted*. (2002).
- Hertz, JA., Krough, AS. and Palmer, RG. *Introduction to the Theory of Neural Computation*. Addison-Wesley, Redwood City (1991).
- Hessler, NA. and Doupe, AJ. Social context modulates singing-related neural activity in the songbird forebrain. *Nature Neuroscience*. I 2 (3), 209-211 (1999a).
- Hessler, NA. and Doupe, AJ. Singing-related neural activity in a dorsal forebrain-basal ganglia circuit of adult zebra finches. *J. Neuroscience*. 19 (23), 10461-10481 (1999b).
- Ho, CE., Pesaran, B., Fee, MS. and Mitra, PP. Characterization of the structure and variability of zebra finch song elements. 5th Annual Joint Symposium on Neural Computation. (May 16, 1998).
- Houde, JF. and Jordan, MI. Sensorimotor adaptation in speech production. *Science*. 279, 1213-1216 (1998).
- Hubel, DH. and Wiesel, TN. Receptive fields of single neurons in the cat's striate cortex. J. Physiol. London. 148, 574-591 (1959).
- Immelmann, K. Song development in the zebra finch and other estrildid finches. *Bird vocalizations (Hinde, R.A., editor)*. Cambridge, England: Cambridge University Press (1969).

- Jarvis, ED., Scharff, C., Grossman, MR., Ramos, JA. and Nottebohm F. For whom the bird sings: Context-dependent gene expression. *Neuron*. 21 (4), 775-788 (1998).
- Johnson, DH., Gruner, CM., Baggerly, K. and Seshagiri, C. Information-theoretic analysis of neural coding. *J. Computational Neuroscience*. 10 (1), 47-69 (2001).
- Kadambe, S. and Boudreauxbartels, GF. Application of the wavelet transform for pitch detection of speech signals. *IEEE Trans. Information Theory.* 38 (2), 917-924 (1992).
- Kelley, DB. and Nottebohm, F. Projections of a telencephalic auditory nucleus in the canary. J. Comp. Neurology. 183, 455-470 (1979).
- Konishi, M. PhD Thesis. University of California, Berkeley. (1963).
- Konishi, M. Birdsong: from behavior to neuron. *Annual Review of Neuroscience*. 8, 125-170 (1985).
- Konishi, M. The role of auditory feedback in the control of vocalization in the Whitecrowned sparrow. Z. Tierpsychol. 22, 770-783 (1965).
- Krichevsky, RE. and Trofimov, VK. The performance of universal encoding. *IEEE Trans. Information Theory.* IT-27, 199-207 (1981).
- Leonardo, A. and Konishi, M. Decrystallization of adult birdsong by perturbation of auditory feedback. *Nature*. 399, 466-470 (1999). [Chapter 3]
- Leonardo, A. and Konishi, M. An efference copy may be used to maintain the stability of adult birdsong. *In preparation*. (2002). [Chapter 4]
- Leonardo, A. and Fee, MS. Different neuronal ensembles underlie similar vocal outputs in a songbird. *In preparation*. (2002). [Chapter 2]
- Lettvin, JY., Maturana, HR., McCulloch, WS., and Pitts, WH. What the Frog's Eye Tells the Frog's Brain. *Proc. of the IRE.*, 47(11), 1940-51 (1959).
- Lewis, JE. and Kristan, WB. A neuronal network for computing population vectors in the leech. *Nature*. 391 (6662),76-79 (1998).
- Livingston, FS. and Mooney, R. Development of intrinsic and synaptic properties in a forebrain nucleus essential to avian song learning. J. Neuroscience. 17(23), 8997-9009 (1997).
- Marler, P. A comparative approach to vocal learning: song development in white-crowned sparrows. J. Comp. Physiol. Psychology. 71, 1-25 (1970).

- McCasland, JS. Neuronal control of bird song production. J. Neuroscience. 7 (1), 23-39 (1987).
- McCasland, JS. and Konishi, M. Interaction between auditory and motor activities in an avian song control nucleus. *PNAS*. 78 (12), 7815-7819 (1981).
- Margoliash, D. Acoustic parameters underlying the responses of song-specific neurons in the white-crowned sparrow. *J Neuroscience*. 3 (5), 1039-1057 (1983).
- Margoliash, D., Fortune, ES., Sutter, ML., Yu, AC. and Wren-Hardin, B.D. Distributed representation in the song system of oscines: evolutionary implications and functional consequences. *Brain, Behavior, and Evolution.* 44, 247-264 (1994).
- Marler, P. Sensory templates in species-specific behavior. *Simpler networks and behavior, J. Fentress, Ed.* Sinauer, Sunderland, MA. 314-329 (1976).
- Marler, P. and Peters, S. A sensitive period for song acquisition in the song sparrow, Melospize-melodia - a case of age limited learning. *Ethology*. 76, 89-100 (1987).
- Marler, P. and Sherman, V. Inate differences in the singing behavior of sparrows reared in isolaton from adult conspecific song. *Animal Behavior*. 33, 57-71 (1985).
- Myers, C., Rabiner, LR. and Rosenberg, AE. Performance tradeoffs in dynamic time warping algorithms for isolated word recognition. *IEEE Trans. Acoust. Speech.* 28 (6), 623-635 (1980).
- Nordeen, K. and Nordeen, E. Auditory feedback is necessary for the maintenance of stereotyped song in adult zebra finches. *Behav. and Neural Biology*. 57, 58-66 (1992).
- Nordeen, KW. and Nordeen, EJ. Long-term maintenance of song in adult zebra finches is not affected by lesions of a forebrain region involved in song learning. *Behavioral and neural biology*. 59, 79-82 (1993).
- Nottebohm, F. Auditory experience and song development in the chaffinch, Fringilla coelebs. *Ibis.* 110, 549-569 (1968).
- Nottebohm, F., Stokes, TM. and Leonard, CM. Central control of song in the canary. J. Comp. Neurology. 165, 457-486 (1976).
- Okanoya, K. and Yamaguchi, A. Adult bengalese finches require real-time auditory feedback to produce normal song syntax. *J. Neurobiology*. 33, 343-356 (1997).

- Panzeri, S. and Treves, A. Analytical estimates of limited sampling biases in different information measures. *Network Computation and Neural Systems*. 7 (1), 87-107 FEB (1996)
- Panzeri, S., Treves, A., Schultz, S. and Rolls, ET. On decoding the responses of a population of neurons from short time windows. *Neural Computation*. 11 (7), 1553-1577 (1999).
- Price, PH. Developmental determinants of structure in zebra finch song. J. Comp. Physiol. Psychology. 93 (2), 260-277 (1979).
- Rosen, MJ. and Mooney, R. Intrinsic and extrinsic contributions to auditory selectivity in a song nucleus critical for vocal plasticity. *J. Neuroscience*. 20 (14), 5437-5448 (2000).
- Scharff, C. and Nottebohm, F. A comparative-study of the behavioral deficits following lesions of various parts of the zebra finch song system - implications for vocal learning. J. Neuroscience. 11 (9), 2896-2913 (1991).
- Schmidt, MF. and Konishi, M. Gating of auditory responses in the vocal control system of awake songbirds. *Nature Neuroscience*. 1 (6), 513-518 (1998).
- Selim, SZ. and Ismail, MA. K-means-type algorithms: a generalized convergence theorem and characterization of local optimality. *IEEE. Trans. on Pattern Analysis and Mach. Intell.* 1, 81-87 (1984).
- Sossinka, R. and Bohner, J. Song types in the zebra finch. Z. Tierpsychol. 53, 123-132 (1980).
- Solis, MM. and Doupe, AJ. Compromised neural selectivity for song in birds with impaired sensorimotor learning. *Neuron*. 25 (1), 109-121 (2000).
- Sperry, R. Neural basis of the spontaneous optokinetic response produced by visual inversion. J. Comp. Physiol. Psychology. 43, 482-489 (1950).
- Spiro, JE., Dalva, MB. and Mooney, R. Long-range inhibition within the zebra finch song nucleus RA can coordinate the firing of multiple projection neurons. J. *Neurophysiology.* 81 (6), 3007-3020 (1999).
- Suthers, R. Contributions to birdsong from the left and right sides of the intact syrinx. *Nature*. 347, 473-477 (1990).
- Tchernichovski, O., Mitra, PP., Lints, T. and Nottebohm, F. Dynamics of the vocal imitation process: How a zebra finch learns its song. *Science*. 291 (5513), 2564-2569 (2001).

- Tchernichovski, O., Nottebohm, F., Ho, CE., Pesaran, B. and Mitra, PP. A procedure for an automated measurement of song similarity. *Animal Behavior*. 59: 1167-1176 (2000).
- Thomson, DJ. Spectrum estimation and harmonic analysis. *Proc. IEEE*. 70, 1055-1096 (1982).
- Thorpe, WH. The learning of song patterns by birds, with especial references to the song of the chaffinch. *Ibis*, 100, 535-570 (1958).
- Todt, D. and Hultsch, H. Zum Einfluss des vokalen Lernen auf die Ausbildung gesanglicher Repertoires bei Drosselvoegeln. Proc. Int. Symp. Verhaltensbiol., ed. G. Tembrock, R. Sigmund, W. Nichelmann. (1985).
- Troyer, TW. and Doupe, AJ. An associational model of birdsong sensorimotor learning I. Efference copy and the learning of song syllables. *J Neurophysiology* 84 (3), 1204-1223 (2000).
- Vates, GE. and Nottebohm, F. Feedback circuitry within a song-learning pathway. *PNAS*. 92 (11), 5139-5143 (1995).
- Vates, GE., Vicario, DS. and Nottebohm, F. Reafferent thalamo-"cortical" loops in the song system of oscine songbirds. *J. Comp. Neurology*. 380 (2), 275-290 (1997).
- Venkatachalam, S., Fee, MS., and Kleinfeld, D. Ultra-miniature headstage with 6-channel drive and vacuum-assisted micro-wire implantation for chronic recording from the neocortex. J. Neurosci. Meth., 90, 37-46. (1999).
- Vicario, DS. and Nottebohm, F. Organization of the zebra finch song control system: I. Representation of syringeal muscles in the hypoglossal nucleus. J. Comp. Neurology. 271, 346-354 (1988).
- Vicario, DS. and Nottebohm, F. Organization of the zebra finch song control system: II. Function organization of outputs from nucleus robustus archistriatalis. J. Comp. Neurology. 309, 486-494 (1991).
- Vicario, DS. and Simpson, HB. Electrical stimulation in forebrain nuclei elicits learned vocal patterns in songbirds. *J. Neurophysiology*. 73(6), 2602-2607 (1995).
- Vicario, DS. and Yohay, KH. Song-selective auditory input to a forebrain vocal control nucleus in the zebra finch. *J. Neurobiology*. 24 (4), 488-505 (1993).
- von Holst, E. and Mittelstaedt, H. Das Reafferenzprinzip. *Naturwissenschaften*. 37, 464-476 (1950).

- Vu, ET., Mazurek, ME. and Kuo, YC. Identification of a forebrain motor programming network for the learned song of zebra finches. J. Neuroscience. 14 (11), 6924-6934 (1994).
- Wild, JM. Descending projections of the songbird nucleus robustus archistriatalis. J. Comp. Neurology. 338, 225-241 (1993).
- Williams, H. and Mehta, N. Changes in adult zebra finch song require a forebrain nucleus that is not necessary for song production. *J. Neurobiology*. 39 (1), 14-28 (1999).
- Williams, H. and Nottebohm, F. Auditory responses in avian vocal motor neurons a motor theory for song perception in birds. *Science*. 229 (4710), 279-282 (1985).
- Wilson, MA. and McNaughton, BL. Dynamics of the hippocampal ensemble code for space. *Science*. 261 (5124), 1055-1058 (1993).
- Wooley, S. and Rubel, E. Bengalese finches Lonchura-striata-domestica depend on auditory feedback for the maintenance of song. J. Neuroscience. 17, 6380-6390 (1997).
- Yu, AC. and Margoliash, D. Temporal hierarchical control of singing in birds. Science. 273 (5283), 1871-1875 (1996).
- Zhou, B., Green, DM. and Middlebrooks, JC. Characterization of external ear impulse responses using Golay codes. J. of the Acoustic Society of America. 92 (2), 1169-1171 (1992).