遗传 » 2013, Vol. 35 » Issue (4) :468-476 DOI: 10.3724/SP.J.1005.2013.00468

幼年斑马鱼的视觉系统与捕食行为

李小泉, 杜久林

中国科学院上海生命科学研究院神经科学研究所, 神经科学国家重点实验室, 上海 200031

LI Xiao-Quan, DU Jiu-Lin

Institute of Neuroscience and State Key Laboratory of Neuroscience, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai 200031, China

摘要 神经环路的研究是揭示动物行为神经机制的关键。斑马鱼作为一种低等脊椎动物，在神经环路的研究中有着独特优势。文章描述了斑马鱼视觉系统及其下游的神经环路，重点讨论了它们在捕食行为中的可能作用。斑马鱼捕食行为主要依赖于视觉功能，该过程涉及到视觉-运动通路各个层次的神经环路，包括下游的网状脊髓命令神经元、脊髓内部的运动控制环路以及一些亟待研究的功能单元。随着在体记录和操纵神经元活动技术的成熟，以及行为学范式的完善，对斑马鱼捕食行为相关神经环路的研究将在未来数年内迅速发展，同时也将推动神经科学相关研究的进步。

关键词: 斑马鱼 视觉系统 捕食行为 神经环路

Abstract： Studying neural circuits is a crucial step for understanding neural mechanisms underlying animal behaviors. Larval zebrafish is a low vertebrate animal model with incomparable advantages in neural circuit study. In this review, we describe the zebrafish visual system and its downstream targets, with special emphasis on their possible roles in prey capture behavior. Prey capture is executed mainly through the visual system and its downstream circuits, including reticulospinal commanding neurons, motor-controlling circuits within the spinal cord, and other un-identified functional units. With the development of approaches in monitoring and manipulating neuronal activity and behavioral assays, we will get deep insights about neural basis for prey capture in near future, which will shed light on elucidating neural circuit mechanisms of behavior.

Keywords： zebrafish, visual system, prey capture, neural circuit

收稿日期: 2012-12-11; 出版日期: 2013-04-25

基金资助:

国家重点基础研究发展计划(973计划)项目(编号：2011CBA00400)，中国科学院战略性先导科技专项(编号：XDB02040300)资助

通讯作者 李小泉 Email: lxq@ion.ac.cn

引用本文:
李小泉，杜久林. 幼年斑马鱼的视觉系统与捕食行为. 遗传, 2013, 35(4): 468-476.

LI Xiao-Quan, DU Jiu-Lin. Visual system and prey capture behavior of larval zebrafish. HEREDITAS, 2013,V35(4): 468-476.

链接本文:

http://www.chinagene.cn/Jwk_yc/CN/10.3724/SP.J.1005.2013.00468 或 http://www.chinagene.cn/Jwk_yc/CN/Y2013/V35/I4/468

Service
把本文推荐给朋友
加入我的书架
加入引用管理器
Email Alert
RSS
作者相关文章
李小泉
杜久林

[1] Nimmerjahn A, Mukamel EA, Schnitzer MJ. Motor behavior activates Bergmann glial networks. *Neuron*, 2009, 62(3): 400-412.

[2] Zahs KR, Newman EA. Asymmetric gap junctional coupling between glial cells in the rat retina. *Glia*, 1997, 20(1): 10-22.

[3] Newman EA. Calcium increases in retinal glial cells evoked by light-induced neuronal activity. *J Neurosci*, 2005, 25(23): 5502-5510.

[4] Newman EA. Glial modulation of synaptic transmission in the retina. *Glia*, 2004, 47(3): 268-274.

[5] Newman EA. Propagation of intercellular calcium waves in retinal astrocytes and Müller cells. *J Neurosci*, 2001, 21(7): 2215-2223.

[6] Rillich K, Gentsch J, Reichenbach A, Bringmann A, Weick M. Light stimulation evokes two different calcium responses in Müller glial cells of the guinea pig retina. *Eur J Neurosci*, 2009, 29(6): 1165-1176.

[7] Keirstead SA, Miller RF. Calcium waves in dissociated retinal glial (Müller) cells are evoked by release of calcium from intracellular stores. *Glia*, 1995, 14(1): 14-22.

[8] Li Y, Holtzclaw LA , Russell JT. Müller cell Ca2+ waves evoked by purinergic receptor agonists in slices of rat retina. *J Neurophysiol*, 2001, 85 (2): 986-994.

[9] Franze K, Grosche J, Skatchkov SN, Schinkinger S, Foja C, Schild D, Uckermann O, Travis K, Reichenbach A, Guck J. Müller cells are living optical fibers in the vertebrate retina. *Proc Natl Acad Sci USA*, 2007, 104(20): 8287-8392.

[10] Burrill JD, Easter SS Jr. Development of the retinofugal projections in the embryonic and larval zebrafish (*Brachydanio rerio*). *J Comp Neurol*, 1994, 346(4): 583-600.

[11] Xiao T, Roeser T, Staub W , Baier H. A GFP-based genetic screen reveals mutations that disrupt the architecture of the zebrafish retinotectal projection. *Development*, 2005, 132(13): 2955-2967.

[12] Du JL, Wei HP, Wang ZR, Wong ST, Poo MM. Long-range retrograde spread of LTP and LTD from optic tectum to retina. *Proc Natl Acad Sci USA*, 2009, 106(45): 18890-18896.

[13] Sin WC, Haas K, Ruthazer ES, Cline HT. Dendrite growth increased by visual activity requires NMDA receptor and Rho GTPases. *Nature*, 2002, 419(6906): 475-480.

[14] Gahtan E, Tanger P, Baier H. Visual prey capture in larval zebrafish is controlled by identified reticulospinal neurons downstream of the tectum. *J Neurosci*, 2005, 25(40): 9294-9303.

[15] Roeser T, Baier H. Visuomotor behaviors in larval zebrafish after GFP-guided laser ablation of the optic tectum. *J Neurosci*, 2003, 23(9): 3726-3734.

[16] Bollmann JH, Engert F. Subcellular topography of visually driven dendritic activity in the vertebrate visual system. *Neuron*, 2009, 61(6): 895-905.

[17] Niell CM, Meyer MP, Smith SJ. *In vivo* imaging of synapse formation on a growing dendritic arbor. *Nat Neurosci*, 2004, 7(3): 254-260.

[18] Xiao T, Baier H. Lamina-specific axonal projections in the zebrafish tectum require the type IV collagen Dragnet. *Nat Neurosci*, 2007, 10(12): 1529-1537.

[19] Hua JY, Smear MC, Baier H, Smith SJ. Regulation of axon growth in vivo by activity-based competition. *Nature*, 2005, 434(7036): 1022-1026.

[20] Schoonheim PJ, Arrenberg AB, Del Bene F , Baier H. Optogenetic localization and genetic perturbation of saccade-generating neurons in zebrafish. *J Neurosci*, 2010, 30(20): 7111-7120.

[21] Gosse NJ, Nevin LM, Baier H. Retinotopic order in the absence of axon competition. *Nature*, 2008, 452(7189): 892-895.

[22] Vanegas H, Ito H. Morphological aspects of the teleostean visual system: a review. *Brain Res*, 1983, 287(2): 117-137.

[23] Vanegas H, Laufer M, Amat J. The optic tectum of a perciform teleost. I. General configuration and cytoarchitecture. *J Comp Neurol*, 1974, 154(1): 43-60.

[24] Nikolaou N, Lowe AS, Walker AS, Abbas F, Hunter PR, Thompson ID, Meyer MP. Parametric functional maps of visual inputs to the tectum. *Neuron*, 2012, 76(2): 317-324.

[25] Hutson LD, Chien CB. Wiring the zebrafish: axon guidance and synaptogenesis. *Curr Opin Neurobiol*, 2002, 12(1): 87-92.

[26] Meek J. A Golgi-electron microscopic study of goldfish optic tectum. II. Quantitative aspects of synaptic organization. *J Comp Neurol*, 1981, 199(2): 175-190.

[27] Meek J, Schellart NAM. A Golgi study of goldfish optic tectum. *J Comp Neurol*, 1978, 182(1): 89-122.

[28] Scott EK, Baier H. The cellular architecture of the larval zebrafish tectum, as revealed by gal4 enhancer trap lines. *Front Neural Circuits*, 2009, 3: 13.

[29] Scott EK, Mason L, Arrenberg AB, Ziv L, Gosse NJ, Xiao T, Chi NC, Asakawa K, Kawakami K, Baier H. Targeting neural circuitry in zebrafish using GAL4 enhancer trapping. *Nat Methods*, 2007, 4(4): 323-326.

[30] Grupp L, Wolburg H, Mack AF. Astroglial structures in the zebrafish brain. *J Comp Neurol*, 2010, 518(21): 4277-4287.

[31] Kriegstein A, Alvarez-Buylla A. The glial nature of embryonic and adult neural stem cells. *Annu Rev Neurosci*, 2009, 32(1): 149-184.

[32] Sild M, Ruthazer ES. Radial glia: progenitor, pathway, and partner. *Neuroscientist*, 2011, 17(3): 288-302.

[33] Merkle FT, Alvarez-Buylla A. Neural stem cells in mammalian development. *Curr Opin Cell Biol*, 2006, 18(6): 704-709.

[34] Gregg CT, Chojnacki AK, Weiss S. Radial glial cells as neuronal precursors: the next generation? *J Neurosci Res*, 2002, 69(6): 708-713.

[35] Lordkipanidze T, Dunaevsky A. Purkinje cell dendrites grow in alignment with Bergmann glia. *Glia*, 2005, 51(3): 229-234.

[36] Weissman TA, Riquelme PA, Ivic L, Flint AC, Kriegstein AR. Calcium waves propagate through radial glial cells and modulate proliferation in the developing neocortex. *Neuron*, 2004, 43(5): 647-661.

[37] Lam CS, Marz M, Strahle U. *Gfap* and *nestin* reporter lines reveal characteristics of neural progenitors in the adult zebrafish brain. *Dev Dyn*, 2009, 238(2): 475-486.

[38] Zupanc GK, Clint SC. Potential role of radial glia in adult neurogenesis of teleost fish. *Glia*, 2003, 43(1): 77-86.

[39] Bernardos RL, Raymond PA. GFAP transgenic zebrafish. *Gene Expr Patterns*, 2006, 6(8): 1007-1013.

[40] Tomizawa K, Inoue Y, Nakayasu H. A monoclonal antibody stains radial glia in the adult zebrafish (*Danio rerio*) CNS. *J Neurocytol*, 2000, 29 (2): 119-128.

[41] Del Bene F, Wyart C, Robles E, Tran A, Looger L, Scott EK, Isacoff EY, Baier H. Filtering of visual information in the tectum by an identified neural circuit. *Science*, 2010, 330(6004): 669-673.

[42] Zottoli SJ, Hordes AR, Faber DS. Localization of optic tectal input to the ventral dendrite of the goldfish Mauthner cell. *Brain Res*, 1987, 401 (1): 113-121.

[43] Canfield JG, Rose GJ. Activation of Mauthner neurons during prey capture. *J Comp Physiol A*, 1993, 172(5): 611-618.

[44] Sato T, Hamaoka T, Aizawa H, Hosoya T, Okamoto H. Genetic single-cell mosaic analysis implicates ephrinB2 reverse signaling in projections from the posterior tectum to the hindbrain in zebrafish. *J Neurosci*, 2007, 27(20): 5271-5279.

[45] McElligott MB, O'Malley DM. Prey tracking by larval zebrafish: axial kinematics and visual control. *Brain Behav Evol*, 2005, 66(3): 177-196.

[46] Montgomery JC, Macdonald F, Baker CF, Carton AG. Hydrodynamic contributions to multimodal guidance of prey capture behavior in fish. *Brain Behav Evol*, 2002, 59(4): 190-198.

[47] New JG, Alborg Fewkes L, Khan AN. Strike feeding behavior in the muskellunge, Esox masquinongy: contributions of the lateral line and visual sensory systems. *J Exp Biol*, 2001, 204(Pt 6): 1207-1221.

[48] Friedrich RW, Habermann CJ, Laurent G. Multiplexing using synchrony in the zebrafish olfactory bulb. *Nat Neurosci*, 2004, 7(8): 862-871.

[49] Zhang RW, Wei HP, Xia YM, Du JL. Development of light response and GABAergic excitation-to-inhibition switch in zebrafish retinal ganglion cells. *J Physiol*, 2010, 588(Pt 14): 2557-2569.

[50] Wei HP, Yao YY, Zhang RW, Zhao XF, Du JL. Activity-induced long-term potentiation of excitatory synapses in developing zebrafish retina *in vivo*. *Neuron*, 2012, 75(3): 479-489.

[51] Burgess HA, Schoch H, Granato M. Distinct retinal pathways drive spatial orientation behaviors in zebrafish navigation. *Curr Biol*, 2010, 20 (4): 381-386.

[52] Mueller KP, Neuhauss SC. Behavioral neurobiology: how larval fish orient towards the light. *Curr Biol*, 2010, 20(4): R159-161.

[53] Engert F. *Innate attraction and repulsion*. Available from: http://www.mcb.harvard.edu/Engert/research.html.

[54] Bianco IH, Kampff AR, Engert F. Prey capture behavior evoked by simple visual stimuli in larval zebrafish. *Front Syst Neurosci*, 2011, 5: 101-113.

[55] Anderson CW , Nishikawa KC. The roles of visual and proprioceptive information during motor program choice in frogs. *J Comp Physiol A*, 1996, 179(6): 753-762.

[56] Valdez CM , Nishikawa KC. Sensory modulation and behavioral choice during feeding in the Australian frog, Cyclorana novaehollandiae. *J Comp Physiol A*, 1997, 180(3): 187-202.

[57] Kinoshita M, Ueda R, Kojima S, Sato K, Watanabe M, Urano A, Ito E. Multiple-site optical recording for characterization of functional synaptic organization of the optic tectum of rainbow trout. *Eur J Neurosci*, 2002, 16(5): 868-876.

[58] Niell CM, Smith SJ. Functional imaging reveals rapid development of visual response properties in the zebrafish tectum. *Neuron*, 2005, 45(6): 941-951.

[59] Korn H, Faber DS. The Mauthner cell half a century later: a neurobiological model for decision-making? *Neuron*, 2005, 47(1): 13-28.

[60] Kohashi T, Oda Y. Initiation of Mauthner- or non-Mauthner-mediated fast escape evoked by different modes of sensory input. *J Neurosci*, 2008, 28(42): 10641-10653.

[61] Borla MA, Palecek B, Budick S, O'Malley DM. Prey capture by larval zebrafish: evidence for fine axial motor control. *Brain Behav Evolut*, 2002, 60(4): 207-229.

[62] Gahtan E, O'Malley DM. Visually guided injection of identified reticulospinal neurons in zebrafish: a survey of spinal arborization patterns. *J Comp Neurol*, 2003, 459(2): 186-200.

[63] 黄玉斌, 邹苏琪, 殷梧, 王昆, 王晗, 胡兵. 成年斑马鱼OKR行为学分析. 遗传, 2012, 34(9): 1193-1201. 浏览

[64] Sankrithi NS, O'Malley DM. Activation of a multisensory, multifunctional nucleus in the zebrafish midbrain during diverse locomotor behaviors. *Neuroscience*, 2010, 166(3): 970-993.

[65] Wyart C, Del Bene F, Warp E, Scott EK, Trauner D, Baier H, Isacoff EY. Optogenetic dissection of a behavioural module in the vertebrate spinal cord. *Nature*, 2009, 461(7262): 407-410.

[66] McLean DL, Fan JY, Higashijima S, Hale ME, Fetcho JR. A topographic map of recruitment in spinal cord. Nature, 2007, 446(7131): 71-75.

[67] McLean DL, Fetcho JR. Spinal interneurons differentiate sequentially from those driving the fastest swimming movements in larval zebrafish to those driving the slowest ones. *J Neurosci*, 2009, 29(43): 13566-13577.

[68] Huang P, Xiao A, Zhou MG, Zhu ZY, Lin S, Zhang B. Heritable gene targeting in zebrafish using customized TALENs. *Nat Biotechnol*, 2011, 29 (8): 699-700.

[69] Hwang WY, Fu YF, Reyon D, Maeder ML, Tsai SQ, Sander JD, Peterson RT, Yeh JRJ, Joung JK. Efficient genome editing in zebrafish using a CRISPR-Cas system. *Nat Biotechnol*, 2013, 31(3): 227-229.

[70] Kawakami K. Transposon tools and methods in zebrafish. *Dev Dyn*, 2005, 234(2): 244-254.

[71] Orger MB, Kampff AR, Severi KE, Bollmann JH, Engert F. Control of visually guided behavior by distinct populations of spinal projection neurons. *Nat Neurosci*, 2008, 11(3): 327-333.

[72] Naumann EA, Kampff AR, Prober DA, Schier AF, Engert F. Monitoring neural activity with bioluminescence during natural behavior. *Nat Neurosci*, 2010, 13(4): 513-520.

[73] Ahrens MB, Li JM, Orger MB, Robson DN, Schier AF, Engert F, Portugues R. Brain-wide neuronal dynamics during motor adaptation in zebrafish. *Nature*, 2012, 485(7399): 471-477.

[74] Mu Y, Li XQ, Zhang B, Du JL. Visual input modulates audiomotor function via hypothalamic dopaminergic neurons through a cooperative mechanism. *Neuron*, 2012, 75(4): 688-699.

[1] 顾爱华 严丽锋.斑马鱼在再生医学研究中的应用及进展[J]. 遗传, 2013,35(7): 856-866

[2] 彭夕洋 陈婷芳 黄婷 江志钢 吴秀山 邓云.心脏特异表达绿色荧光斑马鱼模型的建立与评估[J]. 遗传, 2013,35(4): 511-518

[3] 谢琳 房萍 林金飞 潘洪超 张帆 申延琴.成年斑马鱼脊髓损伤修复中脑*gdnf*和*nos*基因的表达[J]. 遗传, 2013,35(4): 495-501

[4] 孙永华.第一届全国斑马鱼PI大会在武汉召开[J]. 遗传, 2013,35(4): 549-0

[5] 李方方 李文庆 荆清.G蛋白偶联受体在血管发育中的作用[J]. 遗传, 2013,35(4): 459-467

[6] 王学耕 朱作言 孙永华 赵珏.鱼类核移植与重编程[J]. 遗传, 2013,35(4): 433-440

[7] 佟静媛，柳星峰，贾顺姬.Rbb4l促进TGF-**β**/Nodal信号转导和斑马鱼胚胎的背部发育[J]. 遗传, 2013,35(4): 477-487

[8] 刘新星 张雨田 张博.构建斑马鱼心脏损伤-再生模型的手术方法[J]. 遗传, 2013,35(4): 529-532

[9] 张春霞 刘峰.斑马鱼高分辨率整胚原位杂交实验方法与流程[J]. 遗传, 2013,35(4): 522-528

[10] 孙婷 谢翔 张剑卿 包静 汤川政 雷道希 邱菊辉 王贵学.水平回转培养对斑马鱼血管发育的影响[J]. 遗传, 2013,35(4): 502-510

[11] 李辉辉 黄萍 董巍 朱作言 刘东.斑马鱼研究走向生物医学[J]. 遗传, 2013,35(4): 410-420

[12] 沈延 黄鹏 张博.TALEN构建与斑马鱼基因组定点突变的实验方法与流程[J]. 遗传, 2013,35(4): 533-544

[13] 徐冉冉 张从伟 曹羽 王强.缺失*mir122*抑制斑马鱼肝脏前体细胞向肝细胞分化[J]. 遗传, 2013,35(4): 488-494

[14] 李礼，罗凌飞.以斑马鱼为模式动物研究器官的发育与再生[J]. 遗传, 2013,35(4): 421-432

[15] 黄玉斌，邹苏琪，殷梧，王昆，王晗，胡兵.成年斑马鱼OKR行为学分析[J]. 遗传, 2012,34(9): 1193-1201

Copyright 2010 by 遗传