Visual cue-discriminative dopaminergic control of visuomotor transformation and behavior selection

Yuan-yuan Yao¹,²,⁵, Xiao-quan Li¹, Bai-bing Zhang¹,²,⁵, Chen Yin¹,², Ya-feng Liu⁴, Wei-yu Chen¹,², Shao-qun Zeng⁴ & Jiu-lin Du¹,²,3,*

¹ Institute of Neuroscience, State Key Laboratory of Neuroscience, CAS Center for Excellence in Brain Science, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, 320 Yue-Yang Road, Shanghai 200031, China
² Graduate School, University of Chinese Academy of Sciences, 320 Yue-Yang Road, Shanghai 200031, China
³ School of Life Science and Technology, ShanghaiTech University, 319 Yue-Yang Road, Shanghai 200031, China
⁴ Britton Chance Center for Biomedical Photonics and Department of Biomedical Engineering, Huazhong University of Science and Technology-Wuhan National Laboratory for Optoelectronics, Wuhan 430074, China
⁵ Co-first author
* Correspondence: Dr. Jiu-lin Du, Email: forestdu@ion.ac.cn

Abstract: Animals respond differently to visual cues with distinct ethological meaning, a process usually thought to be achieved through differential visual processing. Using a defined zebrafish escape circuit as a model, we found that behavior selection can be implemented at the stage of visuomotor transformation through a visually responsive dopaminergic-inhibitory neural circuit module. In response to non-threatening visual stimuli, hypothalamic dopaminergic neurons and their positively regulated inhibitory interneurons increase activities, suppressing synaptic transmission from the visual center to the escape circuit. By contrast, threatening visual stimuli inactivate some of these neurons, resulting in dis-inhibition of visuomotor transformation and initiation of escape behavior. The distinct patterns of dopaminergic-inhibitory neural module’s visual responses account for this stimulus-specific visuomotor transformation and behavioral control. Thus, our study identifies a behavioral relevance-dependent mechanism that controls visuomotor transformation and behavioral selection, and reveals that neuromodulation can be tuned by visual cues to help animals generate appropriate responses.

Key words: dopaminergic, neuromodulation, inhibitory, visuomotor transformation, behavior, zebrafish