

Vision Science

视觉科学



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University of Science and
Technology of China Press

当代科学技术基础理论与前沿问题研究丛书

中国科学技术大学
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内 容 简 介

本书收纳了中科大校友的 25 篇关于视觉科学的代表性文章。书的内容主要分为两大部分：I，视觉神经科学；II，视觉感知与认知。其中，第一部分中的 I A 部分(皮层前的处理过程)总共包含六章，分别涉及光感受器退化疾病的恢复、视皮层-顶盖系统的改变、视网膜神经节细胞与外膝体细胞的感受野特性以及视皮层对外膝体的反馈作用；I B 部分(皮层中的处理过程)用九章的篇幅涵盖了视皮层对图像和运动的处理、视皮层中视空间的映射和皮层反应特性的关系、注意的作用、知觉学习以及衰老对视皮层处理的影响等内容；I C 部分(眼动系统)中的三章内容重点介绍了眼动神经元的反应特性和眼动指令信号的可靠性。第二部分包括七章，介绍了基本的视觉感知过程，如早期视觉通路中的分辨能力、对距离的感知、对等亮度条件下彩色运动图形的感知、对拓扑结构的感知以及特征分类等。此外，还涉及计算视觉、视觉工作记忆和蜜蜂的决策制定等主题。

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总 序

侯建国

(中国科学技术大学校长、中国科学院院士、第三世界科学院院士)

大学最重要的功能是向社会输送人才。大学对于一个国家、民族乃至世界的重要性和贡献度,很大程度上是通过毕业生在社会各领域所取得的成就来体现的。

中国科学技术大学建校只有短短的 50 年,之所以迅速成为享有较高国际声誉的著名大学之一,主要就是因为她培养出了一大批德才兼备的优秀毕业生。他们志向高远、基础扎实、综合素质高、创新能力强,在国内外科技、经济、教育等领域做出了杰出的贡献,为中国科大赢得了“科技英才的摇篮”的美誉。

2008 年 9 月,胡锦涛总书记为中国科大建校五十周年发来贺信,信中称赞说:半个世纪以来,中国科学技术大学依托中国科学院,按照全院办校、所系结合的方针,弘扬红专并进、理实交融的校风,努力推进教学和科研工作的改革创新,为党和国家培养了一大批科技人才,取得了一系列具有世界先进水平的原创性科技成果,为推动我国科教事业发展和社会主义现代化建设做出了重要贡献。

据统计,中国科大迄今已毕业的 5 万人中,已有 42 人当选中国科学院和中国工程院院士,是同期(自 1963 年以来)毕业生中当选院士数最多的高校之一。其中,本科毕业生中平均每 1 000 人就产生 1 名院士和 700 多名硕士、博士,比例位居全国高校之首。还有众多的中青年才俊成为我国科技、企业、教育等领域的领军人物和骨干。在历年评选的“中国青年五四奖章”获得者中,作为科技界、科技创新型企业界青年才俊代表,科大毕业生已连续多年榜上有名,获奖总人数位居全国高校前列。鲜为人知的是,有数千名优秀毕业生踏上国防战线,为科技强军做出了重要贡献,涌现出 20 多名科技将军和一大批国防科技中坚。

为反映中国科大五十年来人才培养成果,展示毕业生在科学研究中的最

新进展,学校决定在建校五十周年之际,编辑出版《中国科学技术大学校友文库》,于2008年9月起陆续出书,校庆年内集中出版50种。该《文库》选题经过多轮严格的评审和论证,入选书稿学术水平高,已列为国家“十一五”重点图书出版规划。

入选作者中,有北京初创时期的毕业生,也有意气风发的少年班毕业生;有“两院”院士,也有IEEE Fellow;有海内外科研院所、大专院校的教授,也有金融、IT行业的英才;有默默奉献、矢志报国的科技将军,也有在国际前沿奋力拼搏的科研将才;有“文革”后留美学者中第一位担任美国大学系主任的青年教授,也有首批获得新中国博士学位的中年学者;……在母校五十周年华诞之际,他们通过著书立说的独特方式,向母校献礼,其深情厚意,令人感佩!

近年来,学校组织了一系列关于中国科大办学成就、经验、理念和优良传统的总结与讨论。通过总结与讨论,使我们更清醒地认识到,中国科大这所新中国亲手创办的新型理工科大学所肩负的历史使命和责任。我想,中国科大的创办与发展,首要的目标就是围绕国家战略需求,培养造就世界一流科学家和科技领军人才。五十年来,我们一直遵循这一目标定位,有效地探索了科教紧密结合、培养创新人才的成功之路,取得了令人瞩目的成就,也受到社会各界的广泛赞誉。

成绩属于过去,辉煌须待开创。在未来的发展中,我们依然要牢牢把握“育人是大学第一要务”的宗旨,在坚守优良传统的基础上,不断改革创新,提高教育教学质量,早日实现胡锦涛总书记对中国科大的期待;瞄准世界科技前沿,服务国家发展战略,创造性地做好教学和科研工作,努力办成世界一流的研究型大学,培养造就更多更好的创新人才,为夺取全面建设小康社会新胜利、开创中国特色社会主义事业新局面贡献更大力量。

是为序。

2008年9月

The History and Current Status of Vision Research at USTC

The history of vision research at USTC can be traced back to the last years of the Cultural Revolution (1966 – 1976) when Mr. Deng Xiaoping started to revive the economical, cultural and educational development in China in 1973. Around that time, some Chinese universities started to recruit “worker, farmer, and soldier” students. A few faculty members in the biophysics section of the Physics Department at USTC started contemplating a long-term research plan. Because the physiological mechanism of acupunctural anesthesia was the only research topic allowed by the authorities, the researchers began their first neurophysiological study on the specificity of acupuncture points using an old vacuum tube EEG system.

To gain research experience in electrophysiological research, Shou Tiande was sent to the Institute of Physiology in Chinese Academy of Sciences in Shanghai to learn visual electrophysiology. In the five months period with Yang Xiongli’s Vision Research Group, Shou and his collaborators observed two kinds of sensitivity changes during light adaptation through electrophysiological recordings on carp’s retina, (Yang Xiongli, Shou Tiande, Li Zhenyuan etc, The carp retinal sensitivity change during light adaptation. *Biochemistry and Biophysics* at 1978, 10: 15 – 26). After his return to USTC, Tiande obtained a joint research grant with his colleagues from the Science and Technology Committee of Anhui Province to study the mechanisms and applications of anesthesia on the ear root. The research received “Major Scientific Achievements” awards from both the Chinese Academy of Sciences (1978) and Anhui Province (1978).

Although the “Gang of Four” was removed from their positions in 1976, the scientific spring arrived in China in 1978. It became clear to Shou and his

colleagues that, although they had no choice but to study acupunctural anesthesia during the Cultural Revolution, it was time for USTC to develop its own scientific research program, and to contribute to the reconstruction of science and education in China. To develop a long-term plan, they invited several prominent vision scientists from the Institute of Physiology, including Liu Yumin, Yang Xiongli, Li Chaoyi, to visit USTC and give lectures on the current and future directions of vision research. After carefully listening to the lectures and going over and discussing their recordings many times, the faculty in the biophysics section decided that vision research would be the long-term direction of their program. They also decided to immediately send Ruan Diyun to the Institute of Physiology in Shanghai (Li Chaoyi's Lab), Zhang Daren and Xue Jintang to the Institute of Biophysics in Beijing (Wang Shurong's and Diao Yuncheng's labs), to learn visual physiology and biophysics; and Chen Lin to the Institute of Biophysics (Wang Yunjiu's lab) to learn biological control theory and computational neuroscience. These professional development activities in the late 70's resulted in the most important building blocks of the vision research program at USTC.

In 1979, China finally opened its door to the world. Vision researchers at USTC were selected by the Chinese Academy of Sciences to gain research experience in Western countries; Shou Tiande was sent to Professor Enroth-Cugell's Lab at Northwestern University to conduct electrophysiological study in the visual central nervous system in 1980; Chen Lin was sent to University of California at San Diego, Ruan Diyun to University of Houston, Zhang Daren to Oxford University in the United Kingdom, Xue Jintang to University of California at Berkeley, to conduct visual psychophysics and neurophysiology research. Since these researchers had already gained quite a bit of vision research experience before they went abroad, they not only obtained more systematic scientific training but also made some important contributions in the frontiers of vision research during their training period (at least two years) in the host laboratories; their return to USTC was critical to vision research at USTC. One of the most important achievements is a sole-authored publication of "Topological Structure in Visual Perception (1982, Chen)" by the then young lecturer, Chen Lin, in *Science* during his years in the United States. He was promoted to full Professor at USTC in 1985.

Brief Introduction to the Vision Research Lab at USTC

Shou Tiande was the first to return to USTC. With minimum support, he established the Vision Research Laboratory at USTC in 1982, and started research on visual information processing in the central nervous system. He and his colleagues used extracellular electrophysiological recordings in combination with microelectrophoresis, and morphological methods to study the receptive field properties of cat retinal ganglion, lateral geniculate nucleus, and visual cortical cells. They also studied visual development, and changes of visual functions associated with acute elevation of intraocular pressure. Using primitive equipment, most made by themselves, Shou Tiande, Ruan Diyun, Zhang Daren, Xue Jintang, and Shou's first graduate student, Zhou Yifeng, conducted some in-vivo electrophysiological experiments in the cat central nervous system. They found that the receptive fields of cat LGN neurons were oriented toward fovea. The results were published in *Experimental Brain Research* in 1986 — that was the first publication of the Vision Research Lab at USTC in an international journal. The paper has been widely cited. More than 100 researchers, including Nobel Prize winner Torsten Wiesel, asked for reprints. The publication is a milestone in the history of vision research at USTC. From that point on, vision research at USTC is on the international stage.

Training vision researchers has also been a priority at USTC since the beginning of the vision research program. The first undergraduate neurophysiology class was offered in 1982, with a textbook written by the faculty at USTC. At the time, the course generated a lot of interests in China. Today, many a now prominent young and middle-aged Chinese scientists still talk about the impact of the textbook on their career when they recall their college years. The course won an “Outstanding USTC Course” award in 1995. Currently, the Vision Research Lab at USTC offers a number of vision related courses, including Theories of Visual Information Processing, From Neuron to Brain, Principles of Neural Development, and Visual Neuroscience, as part of Master (since 1989) and PhD (since 1993) degree programs in Biophysics. In the last 20 + years, USTC has nurtured a large number of researchers in

neuroscience and especially visual neuroscience.

In 1987, Shou Tiande visited Audie Leventhal's lab at the University of Utah to conduct research on orientation and direction selectivities of subcortical neurons in the visual system, starting a 20-year collaborative research program between the two laboratories. Although the visual system processes information in luminance, color, shape, motion and stereo vision, orientation and direction selectivities, critical for shape and motion perception, are two of the most fundamental visual functions. Since Hubel and Wiesel's pioneering work in the early 1960s, orientation and direction sensitivities in higher mammals have been thought to originate from the primary visual cortex. The collaborative research showed that orientation and direction selectivities exist at subcortical levels. The subcortical selectivities contribute partially to the strong orientation and direction selectivities of cortical neurons. The Vision Research Lab at USTC did a lot of ground-breaking work in this area. The Lab has published more than 20 papers in important national and international journals, including three papers in the *Journal of Neuroscience*. The research has generated a lot of interests in the international vision research community. Some of the major papers have been cited more than 200 times. Researchers in the Lab, Shou Tiande, Zhou Yifeng, Hu Bing, and Li Xiangrui, won the Natural Science Award (second prize) from the Chinese Academy of Sciences in 1997.

The other line of research, effects of acute elevation of intraocular pressure on the functions and morphology of the visual system, also continued in the Vision Research Lab. One of the major studies showed that, different from chronic intraocular hypertension, the Y-type cat retinal ganglion and LGN cells are more tolerant than X-type during acute elevation of intraocular pressure. Seven papers have been published in key vision research journals, including three in *IOVS*, since 1984.

In 2000, USTC Alumni, Professor Lu Zhong-lin from the Department of Psychology at University of Southern California visited the Vision Research Lab, starting another long-term collaboration. In 2001, Professor Lu and Zhou Yifeng obtained an Outstanding Young Scientist Grant (B) from the Natural Science Foundation of China to study the physiological basis of perceptual learning. Based on the long-term experience with amblyopia in the

Vision Research Lab and Lu's expertise on visual perception and perceptual learning, the research program aimed to understand the mechanisms of visual impairments in amblyopia and to develop treatment procedures to improve visual functions of adult amblyopes. After the successful completion of the Outstanding Young Scientist Grant (B), Professors Zhou and Lu obtained another Key Grant from the Natural Science Foundation of China to continue their research on amblyopia. So far, the amblyopia project has generated five publications, including three in Vision Research, one in Journal of Vision, and one in the Proceeding of the National Academy of Sciences of the USA. These studies challenged the widely held view that neural plasticity in the visual system diminishes with age after the sensitive period, and older child and adult amblyopia is no longer subject to therapeutic modifications. The studies revealed remarkable plasticity in the older child and adult amblyopic visual system and suggests that perceptual learning could lead to substantial improvements of spatial vision in older child and adult amblyopia. The research program also produced three PhDs: Huang Changbing, Xu Pengjing, Qiu Zhuping.

The collaboration between Vision Research Lab and Professor Leventhal's lab entered a new era in 2002, when the University of Utah awarded an NIH subcontract to USTC to study the neural mechanisms and possible remedies of aging in the mammalian visual system (with Professor Ma Yuanye in the CAS Kunming Institute of Zoology). Additional funds from the Natural Science Foundation (International Collaborative Funds) were obtained in 2005. The results from the collaborative project provide more evidence on age-related neuronal degradation in the visual system, and may lead to clinical applications in delaying effects of aging in the sensory, motor, and cognitive systems. Eight papers have been published from this collaboration, including one in Science, one in Cerebral Cortex, and one in Neurobiology of Aging. The Science paper was selected as a "must-read" in the "Faculty of 1000 Biology". The Neurobiology of Aging paper was selected as one of "China's 100 Most Influential International Research Papers", by the Institute of Science and Technology Information of China. The project also produced three PhDs: Hua Tianmiao, Yu Shan and Wang Hao.

Since its establishment in 1982, the Vision Research Lab at USTC has

completed more than 30 research projects, with grant support total more than 8 million yuan. The Lab has published 60 papers in international and 40 in national journals, with more than 400 citations. Members of the Lab won many national awards. Five courses have been taught by members of the lab; one of them won a course award from the University. The lab has produced more than 50 bachelor's thesis, 18 master thesis, and 21 PhD dissertations. Currently, there are 11 master and 11 PhD students in the lab. Among the graduates from the lab, many have become leaders in vision research in China: Zhou Yifeng (Professor, USTC), Han Shihui (Professor, Peking University), Hu Bing (Professor, USTC), Wang Wei (Professor, Institute of Neuroscience, Shanghai), Yang Yupeng (Professor, USTC), and Yu Hongbo (Professor, Fudan University).

Brief Introduction to Cognitive Science Lab at USTC

Chen Lin established the Cognitive Psychology Lab at USTC when he returned to China in 1983. Zhang Daren joined the lab when he came back from Oxford University in 1986. In 1988, Chen Lin started a new Cognitive Science Lab in Graduate School of USTC in Beijing. The lab later moved to the Institute of Biophysics in the Chinese Academy of Sciences in 2002. In 2005, Chen Lin joined forces with others and established the National Key Laboratory of Brain and Cognitive Science, with Chen Lin as the Director. Zhang Daren stays at USTC and continues to engage in cognitive science research. His lab was re-named the Cognitive Neuropsychology Lab.

In collaboration with Professors Hu Xiaoping and He Sheng at the University of Minnesota, the Cognitive Neuropsychology Lab at USTC and the Affiliated Hospital of Anhui Medical University (MRI) organized a Joint Lab for Brain Function and Medical Imaging, with Hu Xiaoping as the Director, Zhang Daren and Zhou Jiangning as co-Directors, and Chen Xiangchuan, an Associate Professor, as a principal member. In 1999 and 2003, Hu Xiaoping and He Sheng, in collaboration with Zhang Daren, successively obtained Outstanding Youth Grants (B) from the Natural Science Foundation. Using functional magnetic resonance imaging (fMRI), EEG and behavioral methods, they completed a number of studies on visual attention and working memory, including the effect of visual attention

load on the processing of unrelated auditory interference (Neuroimage, 2006), cross-modal temporal order memory for auditory digits and visual locations (Human Brain Mapping, 2004), binding of verbal and spatial information (Neuroimage, 2007), attentional shift in working memory (Neuroimage, 2004; Brain Research, 2006; JEP – LMC, 2007), and effect of non-temporal visual stimuli on time estimation (Journal of Vision, 2007). Many graduate students, Zhang Peng, Zhang Xiaochu, Wu Xiang, Li Zhihao, Bao Min and Xuan Bin, participated in these projects. All of them have finished their PhDs. In addition, as a joint PhD student, Chen Xiangchuan was trained in He Sheng's lab from 2001 to 2003. He obtained some very interesting results on binocular rivalry (Current Biology, 2004; Vision Research, 2003).

Vision Research at USTC: Historical Highlights

1978: Vision research was chosen as the long-term research direction of the Biophysics section at USTC. Faculty members of the section were sent to related labs in the Chinese Academy of Sciences for professional development.

1982: Shou Tiande established the Vision Research Lab at USTC.

1983: Chen Lin established the Cognitive Psychology Lab at USTC.

1984: Chen Lin established the first experimental psychology lab at USTC. The lab is highly related to vision research.

1985: The first master student in the Vision Research Lab, Zhou Yifeng, graduated (degree awarded by CAS Institute of Physiology). Zhou was later named as a "Master with Outstanding Contribution" in 1991.

1986: The first vision research paper from the Vision Research Lab was published in Experimental Brain Research.

1988: Obtained the first research grant from the Natural Science Foundation of China.

1988: Chen Lin moved to Beijing, establishing the Cognitive Science Lab in the Graduate School of USTC in Beijing.

1989: The National Academic Degrees Committee approved the Master of biophysics degree program at USTC. The program is mostly based on vision research.

1991: Zhou Yifeng obtained the joint USTC-Utah PhD. He is the first

PhD in Department of Biology at USTC.

1993: The National Academic Degrees Committee approved the PhD of biophysics degree program at USTC.

1997: Shou Tiande moved to Fudan University, establishing the Center of Brain Research at Fudan University. Zhou Yifeng is named the Director of the Vision Research Lab at USTC.

2001: Professor Lu Zhong-lin at University of Southern California, together with the Vision Research Lab, obtained a National Outstanding Young Scientist Grant (B), to investigate the physiological basis of visual perceptual learning and amblyopia.

2002: Biophysics at USTC became a National Key Disciplinary program.

2002: The Cognitive Science Lab directed by Chen Lin moved to the Institute of Biophysics in the Chinese Academy of Sciences.

2002: Started the collaboration with Professor Leventhal of University of Utah on the mechanisms of aging in the mammalian visual system. The project was funded by a NIH subcontract from the University of Utah and the Natural Science Foundation of China.

2005: "Mechanisms of Visual Impairment in Amblyope" was funded as a key project by the Natural Science Foundation of China.

2007: The paper in Neurobiology of Aging was selected as one of the China's 100 Most Influential International Research Papers by the Institute of Science and Technology Information of China.

2008: Proceedings of the National Academy of Science of USA published paper on amblyopia, with the Visual Research Lab at USTC as the first institute.

中国科大的视觉研究历史可以追溯到“文化大革命”(1966—1976)后期,即邓小平同志在1973年复出后,全面整顿和恢复国内几乎完全被破坏的经济、文化和教育事业的阶段。这个时期,部分大学已开始招收“工农兵”学员,“复课闹革命”了。这时,科大物理系的生物物理教研室的部分教师开始考虑做些科研活动,为将来的事业发展做些什么。当时对针刺麻醉的机理研究几乎是唯一的被当局所许可的研究项目,所以这些教师使用一台旧的电子管脑电图仪开始了初步的电生理探索针刺穴位特异性的尝试。

为学习电生理学实验的经验,寿天德被派往中国科学院上海生理研究所进修视觉电生理。在该所视觉组的杨雄里实验室工作的5个月里,他们在视网膜电图记录中,发现鲫鱼视

网膜敏感度在明适应过程中的两种变化现象^①。寿回科大后,和大家一起从安徽省科委申请到研究经费,开始了对“耳根环麻醉镇痛原理和临床应用”的研究工作,并取得了一定的成果,后来获得了中国科学院重大科研成果奖(1978)和安徽省重大科研成果奖(1978)。

1976年,“四人帮”垮台,但积重难返,科学的春天直到1978年才姗姗来迟。此时寿天德等认为,“文革”期间全国上下都搞针刺麻醉镇痛的局面是不得已而为之,现在科学的春天来临了,作为中国科大这样的学校,应该选择自己科研发展的长期方向,才能为国家的科学、教育的复兴作出应有的贡献。为此,他们对今后长期研究方向进行了一系列调研,包括特别邀请了中国科学院上海生理所的视觉科学家刘育民、杨雄里、李朝义等来合肥访问和做学术报告,介绍当时国际视觉研究的现状、重大进展和发展趋势。同时,对这些报告做了录音和文字整理,并在事后进行了充分的研讨。最后决定,将视觉研究作为中科大生物物理专业发展的长期方向。方向既定,便立即决定派阮迪云到上海生理所(李朝义实验室),张达人和薛晋堂到北京生物物理所(分别在王书荣和刁云程实验室)进修视觉生理学和生物物理学实验研究,同时,派陈霖到北京生物物理所(汪云九实验室)进修生物控制论和计算神经科学。20世纪70年代末的这些有力的举措为科大的视觉研究发展奠定了坚实的人才基础。

1979年开始,中国的大门终于向世界开放了。经过国家的考试,寿天德于1980年春节后被中国科学院选派往美国西北大学(Northwestern University)生物医学工程中心的Enroth-Cugell教授实验室进修视觉中枢电生理学。随后几年间,陈霖被选派到美国Univ. California at San Diego,阮迪云到Univ. Houston,张达到英国Oxford Univ.,薛晋堂到Univ. California at Berkeley进修,从事视觉的实验心理学和视觉神经生理学研究。他们在国内时已经有了较好的视觉科研基础,在国外著名的实验室工作(两年以上)中,不仅进一步得到了严格的科学研究的训练,而且在视觉研究的前沿获得了不少成果,因此回国后对科大视觉研究的发展起了关键的作用。尤其突出的是,年轻的讲师陈霖在美进修期间,在Science上独立地发表了题为“Topological structure in visual perception”(1982, Chen),为科大,也为国家争得了荣誉。他后来因此1985年被科大破格晋升为教授。

视觉研究实验室简介

1982年寿天德首先回国,在当时艰苦的条件下,在科大建立了视觉研究实验室,确定以研究视觉信息处理的中枢机制为主要的研究方向。他和同事们用细胞外记录电生理方法,结合微量电泳、形态学方法研究猫视网膜神经节细胞、丘脑外膝体细胞和视皮层细胞的视觉感受野反应特性;同时也研究视觉功能发育,以及急性眼内压升高时的视觉功能变化等问题。他和阮迪云、张达人、薛晋堂以及他的第一个研究生周逸峰,用简陋的仪器包括自己制作的视觉刺激器和微电极拉制器,进行了整体动物的中枢电生理实验。1986年在Exp. Brain Res.上发表了科大第一篇在国际脑科学学术刊物上的文章,报道了猫外膝体神经元感受野的方位倾向性呈现指向视网膜中心区的“向心规律”。文章发表后,索取文章单行本的信件逾100份,

^① 杨雄里,寿天德,李震元等. 鲫鱼视网膜敏感度在明适应过程中的变化[J]. 生物化学与生物物理学报, 1978; 10, 15-26.

来信人包括 Torsten Wiesel 在内,并被广泛引用。从此,开始了科大视觉实验研究的历史。

与此同时,科大开始了培养视觉神经科学人才的工作。自 1982 年开始,科大就首先开设了本科生“神经生理学”课程并编写了相应的教材,这在当时国内影响很大。现在很多有成就的中青年科学家在回忆自己成长过程时均提到此书,相关课程已于 1995 年荣获科大首批优秀课程奖。此后以视觉研究实验室为主又开设了“视觉信息处理原理”、“From Neuron to Brain”、“神经发育原则”、“视觉神经科学”等等。以后经过多年努力,先后申报获得了生物物理专业的硕士(1989)、博士学位授予权(1993)。20 多年来为我国培养了大批脑科学方面的,特别是视觉神经科学方面的人才。

1987 年寿天德去美国犹他大学 Audie Leventhal 教授实验室从事有关视觉系统皮层下方位、方向选择性的合作研究,开始了双方长达 20 年的合作关系。视觉系统处理的基本信息包括:亮度、颜色、形状、运动(方向、速度)和立体视觉(深度或三维)等,与形状和运动知觉有关的方位、方向选择性是视觉系统最重要的功能之一。自 20 世纪 60 年代初 Hubel 和 Wiesel 的先驱工作以来,人们通常认为高等哺乳动物的视觉方位、方向选择性主要起源于视皮层细胞,是视皮层细胞的特有功能。视觉研究实验室和 Leventhal 教授实验室的合作研究工作表明,视觉皮层下细胞的方位、方向敏感性是客观存在的,且对视皮层细胞很强的方位、方向选择性和方位功能柱的形成有一定的贡献。视觉研究实验室在丘脑外膝体细胞的方向、方位敏感性方面做出了许多有独创性的工作,在国内外核心刊物发表论文二十余篇,其中三篇论文发表在 *Journal of Neuroscience* 上,发表后引起了国际上的广泛兴趣和重视,主要文章已被国际同行引用 200 余次。该工作于 1997 年获中国科学院自然科学奖二等奖,获奖人是视觉研究实验室的寿天德、周逸峰、胡兵和李祥瑞。

视觉研究实验室从 1984 年开始还研究了眼内压升高对视觉系统功能和形态影响的研究,他们发现与慢性眼内压升高时相反,猫 Y 型视网膜神经节细胞和外膝体细胞对短时程眼内压升高比 X 型有更高的耐受性等有意义的实验结果,在这一研究方向发表核心刊物论文 7 篇,其中三篇发表在视觉研究和眼科领域权威刊物 *IOVS* 上。

2000 年,科大校友美国南加州大学心理学系的吕忠林教授来访,开始了双方的长期合作关系,吕忠林教授与视觉研究实验室周逸峰合作于 2001 年申请到了国家杰出青年基金(B 类)资助,开展有关知觉学习神经机制的研究工作。在视觉研究实验室长期从事有关弱视研究和吕忠林教授长期从事知觉学习研究的背景下,双方合作开创了弱视认知损害机制及可能的恢复途径的研究方向,从理论和实践上探讨用知觉学习原理治疗成人弱视的方法。在顺利完成国家杰出青年基金(B 类)的基础上,双方合作申请的项目“弱视认知损害机制的研究”得到了国家基金委重点项目资助。从 2006 年以来双方合作在该研究方向发表研究论文 5 篇,包括 *PNAS* 和 *Journal of Vision* 各一篇及 *Vision Research* 三篇。这些工作对目前广泛接受的一个观点提出了挑战。一般认为,在发育关键期以后,视觉系统几乎不再具有神经可塑性,因而超过关键期的儿童和成人弱视几乎是不可能治疗的。我们的工作表明大龄儿童弱视和成人弱视患者的视觉系统具有明显的可塑性,因而知觉学习可以显著改善大龄儿童和成人弱视患者的视力。本研究方向培养博士三名(黄昌兵、徐鹏景和仇祝平)。

从 2002 年起,视觉研究实验室与 Leventhal 教授实验室的合作研究进入了一个更为深入的新阶段,视觉研究实验室承担为了美方 NIH 项目的子课题,与中科院昆明动物所马原野研

究员一起合作从事有关哺乳动物视觉系统衰老的神经机制及可能的延缓途径的研究,2005 年又合作申请到了国家基金委重大国际合作项目资助,2003 年以来合作发表国际核心刊物论文 8 篇,包括 *SCIENCE*, *Cerebral cortex* 和 *Neurobiology of Aging* 各一篇,其中发表在 *SCIENCE* 上的论文被国际权威评估体系“Faculty of 1000 Biology”入选,列为“必读”;发表在 *Neurobiology of Aging* 上的论文被科技部中国科学技术信息研究所评选为第一届“中国百篇最具影响优秀国际学术论文”之一。该工作从单细胞水平研究老年猴、老年猫视皮层细胞的功能衰退,探索了老年猴视皮层异常可能的恢复途径,研究结果加深了对哺乳动物视觉系统衰老神经机制的理解,对于延缓由老龄化所引起的感觉、运动和认知衰退有一定的理论意义和应用前景。本研究方向培养博士三名(华田苗、余山和汪浩)。

视觉研究实验室成立以来共承担各类研究课题 30 余项,总经费 800 多万元,发表国内外核心刊物论文 100 余篇,其中国际核心刊物论文 60 余篇,被国际同行引用 400 次以上。曾获得中国科学院自然科学二等奖和一些个人奖项。开设了五门以上课程,曾荣获科大首批优秀课程奖。共指导学士论文 50 余篇,硕士论文 18 篇,指导或合作指导博士论文 21 篇,另有在读硕士生、博士生各 11 名。本实验室毕业的研究生中,周逸峰(科大研究员)、韩世辉(北大教授)、胡兵(科大教授)、王伟(上海神经科学研究所研究员)及杨昱鹏(科大教授)已成为国内视觉研究领域的学术带头人,俞洪波也即将回复旦大学任教授。

中国科大认知科学实验室简介

1983 年陈霖从 UCSD 回国,在中科大建立与视觉密切相关的认知心理学实验室;1986 年张达人从牛津大学回国,加盟该实验室。1988 年陈霖在科大北京研究生院建立了认知科学实验室,行政关系仍隶属于中国科大。2002 年陈霖领导的北京认知科学开放实验室隶属关系离开了中国科大,加盟中科院生物物理所,2005 年与其他实验室一起组建了以陈霖为主任的脑和认知科学国家重点实验室。张达人留在科大生物系继续从事有关认知科学的研究,实验室命名为认知神经心理学实验室。

1999 年,科大(认知神经心理学实验室,张达人)、安医(MRI)与 University of Minnesota 的胡小平和何生教授合作,建立了脑功能与医学成像联合实验室。胡小平教授任主任,张达人和周江宁教授任副主任,主要成员还有陈湘川副教授。胡小平和何生与张达人合作,先后于 1999 年和 2003 年获得 2 项国家杰出青年基金(B 类)资助。主要采用功能核磁成像(fMRI)、脑电和行为学方法,在国内完成了多个高级视觉功能——主要是关于视觉注意和工作记忆的实验和论文,如视觉注意负载对无关听觉干扰处理的影响(*Neuroimage*, 2006);跨视觉-听觉通道的时间次序的工作记忆(*Human Brain Mapping*, 2004);语音-空间信息的整合(*Neuroimage*, 2007);工作记忆中的注意转移(*Neuroimage*, 2004; *Brain Research*, 2006; *JEP - LMC*, 2007);非时间维度视觉刺激的数量信息对时间估计的影响(*Journal of Vision*, 2007)。完成上述实验的主要研究生分别是张朋、张效初、吴翔、李至浩、鲍敏和宣宾,他们都已获得博士学位。此外作为联合培养博士生,陈湘川 2001—2003 年,到何生教授的实验室工作,他们在有关双眼竞争实验中获得有意义的结果(*Current Biology*, 2004; *Vis Res.*, 2003)。

中国科学技术大学视觉研究大事记

1978 年 确立将视觉研究作为中科大生物物理专业发展的长期方向,开始选派教师到中国科学院相关实验室进修;

1982 年 寿天德在科大建立了视觉研究实验室;

1983 年 陈霖在中科大建立与视觉密切相关的认知心理学实验室;

1985 年 独立地培养了首位硕士周逸峰(学位由中科院上海生理所授予),也是生物系培养的首批硕士之一;并在 1991 年被评为“作出杰出贡献的中国硕士学位获得者”;

1986 年 在 *Exp. Brain Res.* 上发表了中科大视觉研究领域第一篇国际学术刊物论文;

1988 年 获国家基金委重大项目子课题资助;

1988 年 陈霖调动工作,在科大北京研究生院建立了认知科学实验室,仍隶属于中国科大;

1989 年 国家学位委员会批准科大以视觉神经生物学为核心的生物物理硕士学位点;

1991 年 周逸峰获中科大视觉研究实验室与美国犹他大学联合培养博士学位,是生物系首位博士学位获得者;

1993 年 国家学位委员会批准科大以视觉神经生物学为核心的生物物理博士学位点;

1997 年 寿天德调离中科大到上海复旦大学工作,建立该校脑科学研究中心并担任主任,科大视觉研究实验室由周逸峰负责;

2001 年 美国南加州大学心理学系吕忠林教授与中科大视觉研究实验室合作获得国家杰出青年基金(B类)资助,开始了有关视觉知觉学习机制及弱视认知损害机制的研究;

2002 年 在生物物理博士学位点的基础上,以神经生物物理为核心的生物物理专业被批准为全国重点学科;

2002 年 陈霖领导的北京认知科学开放实验室隶属关系离开了中国科大,加盟中科院生物物理所;

2002 年 与美国犹他大学 Leventhal 教授合作进行有关哺乳动物视觉系统衰老机制的研究,获 NIH 子课题及国家基金委重大国际合作项目资助;

2005 年 “弱视认知损害机制的研究”获国家基金委重点项目资助;

2007 年 视觉研究实验室在 *Neurobiology of Aging* 上发表的一篇论文被科技部中国科学技术信息研究所评选为第一届“中国百篇最具影响优秀国际学术论文”;

2008 年 有关弱视研究的一篇论文以视觉研究实验室为第一单位发表在美国科学院院刊(PNAS)上。