Advances in the study of bird perception and cognition

Day-1

Introduction

Audition

Olfaction

Day-2

Vision

Integration

Conclusion

March 27-28, 2019

21 KOMCEE West Lecture Hall

The University of Tokyo, Komaba

Sponsored by Evolinguistics Program, JSPS, Center for Evolutionary Cognitive Science, CiSHuB, Utidahm, Phisem of The University of Tokyo

Evolinguistics

Mext Grand-in-Aid for Scientific Research on Innovative Areas EVOLINGUISTICS

http://evolinguistics.net/en/

Day-1: March 27 Wed

13:00-13:10 INTRODUCTION

Kazuo Okanoya, The University of Tokyo

13:10-16:10 AUDITION

13:10-13:50 (incl. 10 mins for disucussion)

Hearing and vocalization interact during ontogeny and during phylogeny

Kazuo Okanoya, The University of Tokyo

Ontogeny part: Songbirds require auditory feedback to learn conspecific songs. Work up to 1990 considered auditory feedback is only necessary during juvenile period and once song is crystalized it is not necessary to maintain the intact song. However, findings by myself and others during 1990-2000 changed this notion and it is considered generally that auditory feedback is necessary to maintain adult song. Here I am presenting the work that definitely showed the necessity of auditory feedback in maintaining adult songs in Bengalese finches.

Phylogeny part: Canaries have been bred for songs with specific aesthetics. Canaries in Belgian Wasserslager strain were bred for low frequency songs while those in American singers were bred for higher pitched song. Interestingly, we found that auditory sensitivity in Wasserslager strain was shifted towards lower range and those of American singers was shifted towards higher range. Further more, F1 hybrid between the two strains resulted in two high-frequency ones and 4 low-frequency ones, meaning auditory mechanism may related with simple Mendelian genetics. However, vocal spectrum of hybrid birds rested in the middle of the two parental strains, again meaning it is controlled polygenes.

Hearing and vocalizations are thus tightly linked in songbirds both in ontogeny and in phylogeny.

13:50-14:30 (incl. 10 mins for disucussion)

Messages in Some of the Details: How Birds Listen to Auditory Sequences

Adam Fishbein & Robert J. Dooling, University of Maryland

Humans and many birds produce learned vocal communication signals consisting of basic units (i.e. syllables) arranged in sequences (i.e. words and sentences for humans, motifs and songs for birds). For this reason, casual listeners might think that birds listen to their songs the same way we listen to speech, extracting information primarily from sequential patterns. Here, we show that several songbird species, including zebra finches, are much less sensitive to changes in syllable sequences than to changes in syllable structure. This includes acute sensitivity to natural acoustic variation across renditions of their song syllables, suggesting that their motifs do not sound as repetitive to them as they do to us. It is likely that not all birds are the same regarding these sensitivities. Budgerigars, a parrot species, perform well at hearing sequences, though they focus more on the transitions between acoustic elements (human phonology-like) than abstract structure (human syntax-like). These results highlight the importance of local syllable-level details in birdsong, indicate fundamental differences in avian and human perception of vocal communication signals, and argue for more comparative studies to understand these species differences and the brain mechanisms that support them.

14:30-14:50 Break

14:50-15:30 (incl. 10 mins for discussion)

Statistical and prosodic cues for song segmentation by Bengalese Finches (Lonchura striata var. domestica)

Miki Takahasi, Riken CBS

Juvenile songbirds learn their songs from adults. Birds sometimes learn parts of songs from multiple tutors and recombine these into one song sequence, not simply learn songs as that way. How do they segment a particular part and select that as a chunk and how are these chunks recombined? The song of the Bengalese Finch has complex syntax with variable note-to-note transition probabilities and thus should be suitable for the study of segmentation and chunking in birdsong. Thirty-two male Bengalese Finch chicks were reared in a large aviary where 11 adult tutors and 10 adult females were breeding freely. In this environment most male chicks learned songs from two tutors. The chunks that juveniles copied from original tutor songs had greater transition probability and shorter silent intervals than did the boundaries of the chunks. The result suggested that the Bengalese finches segmented songs using both statistical and prosodic cues. Such segmentation and chunking are also considered to be a basic mechanism in human language acquisition. Thus, the Bengalese finch should prove to be an excellent model in which to study neural and behavioral mechanism for sound segmentation.

15:30-16:10 (incl. 10 mins for discussion)

Mismatch responses in songbird auditory forebrain

Chihiro Mori, JSPS

Learning sound patterns and detection of deviant in natural auditory scene are adaptive to predict future stimuli and change attention that potentially relate behavior. Deviance detection has been studied in several animals using oddball task by comparing the neural response between deviant pure tones that were presented infrequently and standard pure tones that were presented frequently. Java sparrow is highly social and maintains communication with flock members using frequently repeated contact calls and song. Because of this, we chose this species to explore whether auditory neurons are sensitive to violation of transition patterns. We recorded local field potentials in a secondary auditory area, the caudomedial nidopallium (NCM), using both pure tone and natural vocalizations. Significant differences between deviant and standard event related potentials both to pure tone and natural vocalizations were observed. Further, we investigated mismatch response to sound sequence order in NCM in triplet sequence oddball task using contact call. we found the significant negative shift in response to the difference of sequence pattern. Our results suggest mismatch response and the ability to extract sound sequence information in songbird auditory forebrain.

16:10-16:30 Break

16:30-17:20 OLFACTION

The Role of Olfaction for Social Behaviour of Zebra Finches

Hans-Joachim Bischof and Barbara Caspers, Bielefeld University

Songbirds are well known to rely on visual and acoustic cues for communication, and many neurobiological studies have shown that their visual and acoustic neuronal systems are dominating the space of the forebrain. In contrast, the role of the olfactory sense for this group of birds has been underestimated for many years, although there are many studies indicating that there are quite a lot of avian species using olfaction for navigation, orientation and finding of food. Research on zebra finches indeed indicated that these birds obviously do not rely on odour to locate food sources. Instead, olfactory cues are used frequently in social communication, e.g. for the recognition of offspring or parents. In this talk, I shall present some of the results of the Bielefeld research group on olfactory communication in zebra finches, including first attempts to study how social odours are processed in the avian brain.

17:20-18:00 DISCUSSION

18:00-20:00 DISCUSSION WITH DRINK AND SNACKS <MM Hall>

Day-2: March 28 Thu

10:00-12:00 VISION

10:00-10:40 (incl. 10 mins for discussion)

Chasing memory engram in the avian brains:1973-1993

Shigeru Watanabe, Keio University

At first memory localization in one side of hemispheres was examined with pigeons. Birds are suitable animal for such studies because of their completely crossed optic chiasma. Behavioral studies with pigeons displayed successful interocular transfer of visual discrimination. Second, spreading depression (reversible deactivation of one hemisphere) and unilateral hemispherectomy showed unilateral memory after monocular training. Third, selective section of the ventral DSO (decussation supra opticum) but not the dorsal part disrupted the interocular transfer of learning. The ventral part connects the tectofugal visual pathway at the diencephalic level. fourth, unilateral lesion of the trained nucleus rotundus (thalamic nucleus of the tectofugal pathway) but not the dorsal thalamus impaired the interhemispheric transfer. These results suggest unilateral memory and bilateral read-out of the memory in the tectofugal pathway. Finally, integration of the two hemispheres was demonstrated by conditional discrimination in which side of the hemispheres determined discriminative stimulus.

10:40-11:20 (incl. 10 mins for discussion)

Functional Organization of the Zebra Finch Visual Wulst: Comparable with Mammalian Visual Cortex?

Hans-Joachim Bischof, University of Bielefeld

The cortex of mammals is a layered structure which surrounds the other parts of the forebrain. In contrast, avian cortical structures are embedded amids other forebrain structures and layers are, if not absent, not very easy to distinct. However, there is little doubt that cortical areas in birds and in mammals are homologue structures. In the present talk, I want to examine whether, in spite of the big differences in architecture, there are similarities of the function and physiology of two areas supposed to be homologue: the avian visual wulst and the mammalian visual cortex. Instead of presenting a global overview, I shall report our own studies concerning the organization and function of the zebra finch visual wulst and compare it with the literature on the mammalian visual cortex.

11:20-12:00 (incl. 10 mins for discussion)

Tectofugal pathway to the retina: Its role in target detection and selection

Hiroyuki Uchiyama, Kagoshima University

The avian retina receives centrifugal projection indirectly from the optic tectum (OT), and the tectofugal pathway to the retina is composed of three serially-connected neurons; 1) tecto-isthmo-optic (tecto-IO) neurons in the OT, 2) isthmo-optic (IO) neurons in the isthmo-optic nucleus (ION) and 3) IO target cells in the retina. Furthermore, the IO target cells may contact with a particular kind of bipolar cells that are immunoreactive for protein kinase C (PKC-BCs). The IO neurons are passively activated by visual stimuli and are also voluntarily activated just before head movements oriented toward their receptive fields. The activity of the IO neurons, or the centrifugal signal to the retina, facilitates visual responses of the retinal ganglion cells (RGCs) transiently and locally via the IO target cells and perhaps the PKC-BCs. Inactivation of the IO neurons during search and peck task revealed that the centrifugal signal to the retina improved target detection and selection by specific facilitation of visual responses of the RGCs that perceive the target stimulus. Then, topographically-biased distribution of RGCs' population activity with a peak at the target location may correctly induce orienting to the target through visuomotor transformation probably by tecto-bulbar neurons.

12:00-13:00 Lunch

13:00-15:00 INTEGRATION

13:00-13:40 (incl. 10 mins for discussion)

Towards a comparative neurobiology of auditory-to-motor integration

Ryosuke O. Tachibana, The University of Tokyo

Bird's song production requires integrating auditory feedback into vocal motor commands to achieve rapid and accurate control of sound properties, as well as human speech production. To discuss neural mechanisms underlying the audiomotor integration, I will introduce different types of experiments on both songbird and human vocalizations in which the auditory feedback was manipulated in various ways, such as presenting a continuous noise, shifting pitch, and delivering brief noise bursts. The contentious noise presentation elicits an automatic increase of vocal amplitude (known as the Lombard effect). Our study demonstrated the amplitude increase at the syllable level of Bengalese finch's song, while showing a complex nature in the vocal pitch changes. On the other hand, the pitch shift is known to induces compensatory vocal responses. In a study on the human vocalization, we found an interesting tendency that the higher pitch variability predicts the greater compensation against the pitch shift. Further, we studied vocal responses against a time-specific degradation of auditory feedback by superimposing a brief noise onto a target syllable of birdsong. The result suggested that the amount and speed of changes in temporal feature of vocalization can be predicted by the motor variability across performances. These findings suggested a shared neural mechanism among human and songbird vocalizations.

13:40-14:20 (incl. 10 mins for discussion)

Psychological and neural underpinnings for dominance relationship in crows

Ei-Ichi Izawa, Keio University

Recent studies in comparative psychology have revealed that corvids (i.e., crows, jays and magpies) possess extraordinarily large 'cortex' and sophisticated socio-cognitive abilities such as perspective taking, inferring the third-parties' relationship, and empathy-like behaviour. These socio-cognitive abilities of corvids provide a clue to understand the evolutionary triadic linkage among social ecology, communication, and neural underpinnings outside the mammalian lineage. Crows form fusion-fusion societies where the same individuals repeatedly aggregate and diffuse in a wide range of habitat. Such social ecology is assumed as an ecological ground for the evolution of social behaviour to resolve inter-individual conflicts in crows. One typical instance for the conflict resolution is the formation of dominance relationships. Dominance is referred to as the asymmetry of the resource competition ability between individuals, which is characterized by species-specific submission display by one individual toward the opponent (i.e., dominant) in a dyad. In this presentation, I would like to review our findings that formation of dyadic dominance relationship based on the integration of individual recognition and the win/loss outcome in the past encounters, and that the relevance of several pallial/subpallial nuclei and autonomic nervous system (ANS). Finally, I would claim the integrative role of brain and ANS in social behaviour control of birds.

14:20-15:00 (incl. 10 mins for discussion)

Enhanced gene expression by visual and auditory stimuli in songbirds

Maki Ikebuchi, Riken

Many avian species use audio-visual information in the context of social behaviour. When new songs are presented to the birds, the expression of immediate early genes (IEG´s) like c-fos or ZENK is enhanced in auditory areas like the forebrain region NCM. We have compared behaviour and IEG expression in Bengalese finches and in zebra finches, two monogamous species where only males are singing, and examined IEG expression in some areas of the forebrain. Zebra finches are sexually dimorphic in feather color, Bengalese finches are not. In this talk, we present some results of our social behavioural observations and gene expression study indicating that there are some species differences concerning reactions to audiovisual stimuli and also in gene expression.

15:00-15:30 DISCUSSION

15:30-16:00 CONCLUSION

Shigeru Watanabe, Keio University

Scientific Research on Innovative Areas “Evolinguistics” Secretariat
evolinguistics.admin@ecs.c.u-tokyo.ac.jp

Graduate School of Arts and Sciences, The University of Tokyo,
c/o Center of Evolutionary Cognitive Sciences, 3-8-1,
Komaba, Meguro-ku, Tokyo, Japan 153-8902