INITIATING LEARNED VOCALIZATION IS PRECEDED BY LONG RAMPING IN NEURAL ACTIVITY IN BASAL GANGLIA IN A SPECIES OF SONGBIRD

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Learning is essential to speak language. Humans are highly motivated to speak and improve it especially in their childhood. After critical period of language learning, they can still acquire new vocabulary, and even second language. It enables humans to sophisticate abstract and hierarchical language and contributes to communication among or between groups of large size. As well as the capacity of learning, motivation to learn language during their lifetime is needed on improvement of speaking language without being praised or rewarded, especially in their adulthood. It suggests that language learning should be motivated by internal system, and investigating mechanism of motivation of learning would help to understand how human language is maintained and evolved. In the perspective of motivation to maintain learned vocalization, vocal-learners are expected to have common system to vocalize frequently. As well as humans, male songbirds conduct vocal learning both as a child and an adult. Although their song is used to attract females, they also sing undirected song (US), and it has a role in maintain their syntax and acoustic features (Sakata & Brainard, 2006). It suggests that male songbirds are good model to investigate internal system to motivate vocalization. Anterior Forebrain Pathway (AFP), a cortico-basal ganglia-thalamo-cortical loop in songbird, is suggested to learn and maintain US (Brainard, 2004; Ölveczky et al., 2005; Hoffmann et al., 2016; Gadagkar et al., 2016). In AFP, neural activity in Area X, basal ganglia in songbird, is expected to reflect both preparatory activity and motivational signal because it receives premotor and dopaminergic input, and was reported on dopamine concentration during singing US (Sasaki et al., 2006). In order to investigate neural activity reflecting motivation in learned vocalization, present study recorded preparatory

activity in basal ganglia of male songbirds during US, and compared duration of the activity change in US and compared it to that in vocalizing innate call.
Male Java sparrows (Lonchura oryzivora) (n = 4) were used for neural recording. Manually-driven electrode was implanted in their Area X, and neural activity was recorded while they vocalized US and innate calls in a sound-proof box. Neural activity was calculated by firing rate (FR) of sorted unit from recorded data. US bout was composed of motif (main body), and preceding vocalizations. FR in seven 1 second bins before the onsets and one bin after the onsets were used for statistical analysis. FR in 7-6 seconds before the onset was regarded as spontaneous firing rate (SFR), and song-related neurons were decided by Wilcoxon's sign rank test between FR in the bin after onset and SFR. Ramping duration of preparatory activity was decided by the number of continuous bins significantly higher in FR than SFR from the onset. As to innate calls, trill calls, specific long call in Java sparrow, was used in activity analysis. FR in three 1 second bins before the onsets and one bin after the onsets were used for statistical test. 24 neurons were recorded, 16 neurons showed US related activity and 6 showed trill call related activity. Ramping duration of preparatory activity was 2.25 ± 1.56 seconds in US (bout: 2.58 ± 1.55 seconds, motif: 1.25 ± 1.09 seconds), and 1.33 ± 0.47 seconds in trill call. The results shows that longer activity change in basal ganglia before learned vocalization than innate call in songbird. It suggests that initiation of learned vocalization may cause longer change in internal state, and motivate activity increase in various area, which may enables individuals complex and skilled vocalization.

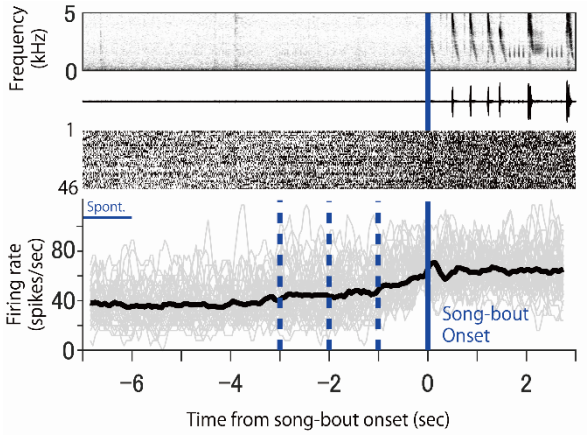

Figure: (Top) Spectrogram and waveform of US. (Middle) Raster plot of neural activity initiating US. (Bottom) Histogram of activity prior to US.

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