Spontaneous temporal coordination during tapping behavior in dyads:
A comparative study in chimpanzees and humans

Lira Yu

Temporal coordination is important in many species, and is seen in behaviors that range from the coordinated group behaviors of bird flocks and fish schools, to the social group behaviors of humans (e.g., in dancing). To understand evolutionary origins of temporal coordination in humans, the current study established a novel experimental method for examining spontaneous temporal coordination in chimpanzees and humans under a social context. Moreover, to understand the causal effect of multimodal cues on the emergence of temporal coordination in both species, an effect of auditory and/or visual cues of the partner's movement was examined under two different experimental setups: the side-by-side setup (Chapter 2) and the face-to-face setup (Chapter 3). A finger-tapping task was introduced as a general method to produce repetitive and rhythmic movement from each participant in the laboratory setup.

In Chapter 2, two pairs of chimpanzee mothers and her biological offspring were examined under the side-by-side setup where only auditory cues of the partner's movement were available. Results indicated that chimpanzees can use auditory cues from their partner for temporal coordination (Yu & Tomonaga, 2015). However, it was difficult to generalize the findings to all chimpanzees, because only one out of four chimpanzees showed both significant tapping tempo change and the tapping alignment toward her partner. I assumed that an effect of auditory cues might have been overshadowed by a long history of conducting independent tasks while ignoring others in the current setup (cf., Matsuzawa, Tomonaga & Tanaka, 2006). To clarify the spontaneous emergence of temporal coordination in chimpanzees, retest was needed under a more interactive experimental setting.

To facilitate an interaction between chimpanzees, I established a new experimental setup, called the face-to-face setup, where both auditory and visual cues of the partner's movement were available (instead of only auditory, as in the prior study). In Chapter 3-1, I examined both chimpanzees (four pairs, including the two mother-offspring pairs who participated in the previous study, as well as two new non-kin pairs) and humans (four non-kin pairs). Results indicated that chimpanzees and humans are similar in that they show unidirectional adaptation in tempo when they simultaneously produce tapping movements with a partner under auditory and visual interaction (see Yu & Tomonaga, 2016). Interestingly, the participants from non-kin relationships in both chimpanzees and humans showed a social facilitation of fast

tapping tempo, whereas the four chimpanzees from mother and offspring pairs showed no such effect. Instead, offspring chimpanzees changed their tempo towards that of their relatively slow tapping mother. In addition to the similarities seen between chimpanzees and humans, the current study revealed a notable difference between two species: whereas tempo convergence occurs rapidly and completely in humans, it is slow and partial in chimpanzees. These findings suggest that chimpanzees and humans share modulations when producing their own rhythmic movement under multimodal interaction with their partner. However, an ability to precisely coordinate the movement in time with their partner developed gradually after human lineage separated from that of chimpanzees.

The findings from Chapter 3-1 support the hypothesis that auditory cues by themselves are sufficient to facilitate coordinated interaction between the chimpanzees (see Chapter 2). However, it remained unclear whether visual cues might also have an effect. In Chapter 3-2, I examined an effect of visual cues in addition to moderate auditory cues of the partner's movement, under the same face-to-face setup in both chimpanzees and humans. Results showed that auditory cues are sufficient for temporal coordination in both chimpanzees and humans, whereas visual cues in addition to the auditory cues have weak additional effect. For clarification, here I note that this does not yet prove that the visual cues do nothing. It could just be that humans and chimpanzees rely on auditory cues, when bimodal cues are available. I assume that if there are only visual cues, with no auditory cues, they would have some effect on temporal coordination in both species. In this study, there was no clear evidence of any interspecies difference between chimpanzees and humans with respect to sensory modality in temporal coordination.

Overall, the current comparative study in chimpanzees and humans demonstrated that chimpanzees have the ability to temporally coordinate their rhythmic movement with those of a partner, an ability they share with humans. The results also show that both species can use auditory cues in perceiving their conspecific partner's rhythmic movement. Although the current thesis did no conduct a detail analysis of possible phase matching, I found clear evidence in both species for a spontaneous change in tempo that led to increased temporal coordination. Taken together, the current studies for the first time provide valuable new evidence that chimpanzees and humans share a common ability for temporal coordination. This provides an important complement to prior studies of temporal coordination in non-human primates, which had so far been limited to chimpanzees examined under a non-social context or monkeys without direct comparisons between species in the same study.