Precursors of Dancing and Singing to Music in Three- to Four-Months-Old Infants

Shinya Fujii,[*1, 2, 3] Hama Watanabe,[2] Hiroki Oohashi,[2, 3] Masaya Hirashima,[2] Daichi Nozaki, [2] Gentaro Taga[2#]

[1]*Department of Neurology, Beth Israel Deaconess Medical Center and Harvard Medical School, USA*
[2]*Graduate School of Education, The University of Tokyo, Japan*
[3]*Research Fellow of Japan Society for the Promotion of Science, Japan*
[*]sfujii@bidmc.harvard.edu, [#]taga@p.u-tokyo.ac.jp

ABSTRACT

Background and Aims

Dancing and singing involve auditory-motor coordination and have been essential to our human culture since ancient times. Recent animal (e.g., dancing cockatoo) studies stress the importance of a tight link between the auditory-motor circuit as a prerequisite for vocal learning and musical synchronization capabilities (Patel et al., 2009; Schachner et al., 2009). A human developmental study has shown significant cortical activity in newborn infants in response to the violation of the beat in a rhythmic sound sequence (Winkler et al., 2009). On the other hand, auditory-motor coordination in musical contexts is assumed to develop later: A recent study on 5- to 24-months old infants mentioned that "movement-to-music synchronization requires a degree of motor control that may not be achieved until preschool age" (Zentner & Eerola, 2010). If human musicality is truly innate and arises spontaneously through entrainment mechanisms between our bodies and the environment (Phillips-Silver et al., 2010), synchronized limb movements and/or altered vocalizations to music should be observed even in infants younger than five months old. Thus, we aimed to examine whether three- to four-months-old infants are able to synchronize movements of their limbs to a musical beat and/or produce altered vocalizations in response to music.

Methods

We investigated thirty full-term healthy infants aged 106-125 days. Additional seventy-seven infants were also collected, but excluded from the analysis due to fussing, crying, rolling over, or system errors. In the silent condition, there was no auditory stimulus, whereas in the music condition, one of the two pop songs was played: "Everybody" by Backstreet Boys, tempo = 108.7 BPM and/or "Go Trippy" by WANICO feat. Jake Smith, tempo = 130.0 BPM. Limb movements and vocalizations of the infants in the spine position were recorded by a 3D motion capture system and the microphone of a digital video camera. Both experimenters and parents were out of the infant's sight during the recording to prevent any social interaction and to investigate pure spontaneous movements. For limb movements, we first quantified the mean square sum velocity of each limb as a measure of the amount of movement made. We also performed power spectrum analysis for limb movements to investigate their frequency components. When the infants moved their limbs continuously for over three seconds, we performed synchronization analysis on the moving section using the synchronization index (a measure of entropy); Monte-Carlo statistics was used to test whether or not the phase synchronization to music occurred by chance. For vocalizations, we assessed the mean duration of vocalizations per minute as a measure of the amount of vocalizations made. We also assessed the mean and standard deviation (SD) of the fundamental and formant frequencies within the infant's utterances to infer the presence of vocal organ movements.

Results

In the group analysis, we found no significant increase in the amount of movement in the music condition compared to the silent condition. Intriguingly, however, there was an infant (ID1) who demonstrated a significant increase in the amount of movement of the right leg when listening to "Everybody": ID1 kicked intensely and rhythmically when the music was played and the data of ID1 was qualified as an outlier. The observed synchronization indices of this individual were significantly above the confidence interval, suggesting that the observed degrees of phase synchronization are unlikely to have occurred by chance. We found no significant difference between the silent and music conditions for the amount of vocalizations. In contrast, we found significant increases in the SDs of formant frequencies in the music compared to the silent condition.

Conclusions

First, we found a striking increase in the amount of limb movements and their significant phase synchronization to the musical beat in one infant, but, as a group, there was no significant increase in the amount of limb movements during the music compared to the silent condition. Second, we found a clear increase in the formant variability of vocalizations in the group during music perception. These results suggest that our brains are already primed with our bodies to interact with music at these months of age via limb movements and vocalizations.

Keywords

Auditory-motor interaction, Synchronization, Development

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