

Comparative Study Between Zebra Finches (*Taeniopygia castanotis*) and Humans

(*Homo-sapiens*): Communication Development

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Abstract

Zebra finch (*Taeniopygia castanotis*) vocalization development is analogous to how human (*Homo Sapiens*) infants develop language. Imitation is a major way song and speech develops, studies have shown that social interaction is also significant to this development. Imitation is the infant or zebra finch attempts to produce their own sound based on their adult mentor. Social interactions facilitate production of sound by infants and juvenile birds. Due to the parallels in songbird communication and human language, studies done to understand vocal development in songbirds can be compared to human studies. Overall, the analogous system of songbirds can help us rework our understanding of early developmental processes in not only birds, but also humans, thus helping our current understanding of the evolution of language and possibly create therapeutic techniques to aid with speech-related injuries.

Basics Of Zebra Finches

The zebra finch (*Taeniopygia castanotis*) is the most common of the eighteen species of Australian grass finches (Waters, 1979). They primarily inhabit Australia and they tend to seek areas where water is available. The diet of the zebra finch consists mainly of seeds and insects; seeds are found as the bird hops on the ground, extracting seeds as they jump. Males are primarily grey with a white abdomen and have multiple black band markings around the cheek, and breast area with an ear patch that is light chestnut. The male bill is red, while females have yellow bills. Female zebra finch has similar markings but the light chestnut ear patch of the male that is absent.

The maintenance activities of the zebra finch, which include preening (grooming) activities, feeding, drinking, and activities that help general health, comfort, and efficiency. Overall, maintenance activities tend to be very brief in correlation with their alertness to surroundings, which can be a result of their vulnerability to raptorial predation (Waters, 1979). For example, zebra finches intake small amounts of water to limit time and reduce vulnerability at a water source. Zebra finches are a type of songbird. A songbird is a group of animals that need exposure to a tutor to learn and eventually produce their elaborate songs and calls.

Communication Development (songbird and human)

Songbirds

Juvenile zebra finches start learning to sing when they are on average 40 days old. An mentor adult zebra finch sings and juveniles mimic their vocalizations (i.e., subsong). Juveniles will reproduce the song and repeat for three months. Hearing themselves sing is a crucial element

of song development as it allows comparison to adult song. Zebra finches' final song (i.e., crystallized song) will be unique. Zebra finches practice their songs in their sleep, and more sleep is an essential part of the song learning process (Wu, 2018). The zebra finches brain works late, vibrating the vocal cords mimicking the practice done during the day.

Humans

The learning processes of the zebra finch may be analogous to how the humans (*Homo-sapiens*) learn their language (Kuhl, 2003). Humans develop their vocal system from imitating an adult mentor (Kuhl, 2003). Both species have to be exposed to species-typical vocalizations or speech during a sensitive period of time to do so. Babies store and memorize species-specific phonetic units and syllables to learn language. Basically, they memorize the ways words are formed and are spoken by their adult mentors. They then must use the patterns stored in memory to guide the development of speech through imitation. Babies then rehearse and refine their repertoires by comparing and gradually matching their production through auditory feedback (Kuhl, 2003).

Vocal Imitation and the Integration of Social Interaction

Speech and song development are parallel between humans and zebra finches. Social interactions and feedback from an adult mentor impact development and feedback make a difference in both the quantity and quality of the utterances that young infants produce (Kuhl, 2003).

Humans

Goldstein, King, and West (2003) conducted an experiment which included 30 infants (6-10 months), and their mothers. The researchers hypothesize that learning cues is important for

early vocal development and thus should be important for other parameters of world learning and language use. Children were placed in a large playroom filled with toys and picture boards. The size of the playroom allowed infants to explore and not force side by side interactions with their mothers. Infants and mothers were split into two groups. These included the Contingent Condition (CC), where mothers reacted immediately after their infant vocalized, and the yoked-controlled condition (YC), where mothers were instructed to respond following a schedule generated by the CC mothers. As a result, both groups received the same amount of social stimulation but the stimulation occurred at different times. Results showed that CC infants significantly increased the number and quality of vocalizations in the social response period. Their speech was more advanced than the speech they produced during baseline testing whereas YC infants vocalized frequently but showed no change in the developmental quality. Based on study, social interaction increased the proportion of vocalizations produced by infants. Vocalizations of the CC infants had more mature voicing, syllable structure, and faster consonant-vowel transitions. Researchers observed that changes in sound production were in a developmentally advanced direction in the CC group. The results of the CC group show that infants' early vocal behavior is sensitive to perturbations of their social environment. The study concludes that babbling is regulated by social interaction. The results of the experiment show a close parallel to the social mechanisms to the songbird and are relevant to the understanding of the neurobiological underpinnings of avian song and human speech. (Goldstein, 2003)

The researchers hypothesize that neural structures must be involved in the speech system that are sensitive to non-auditory feedback. If learning from cues in the social environment is an important part of early vocalizing, then it should be important for early parameters of world

learning and language use. The researchers also suggested that early vocalizations become a way of communication only after young birds or babies come to realize the instrumental value of sound. The similarities in vocal development between birds and babies are the synergy between the response of adults and the capacities of young organisms to use social information to refine their repertoire of song/verbalizations. There is belief that a more complex understanding about vocal oncology will be created by the integration of social contingency within the advancement of vocal development (Goldstein et al., 2003).

Songbirds

Song imitation in birds provides a good opportunity for studying the basic biology of vocal learning because it is easy to apply that knowledge to the human brain when it comes to communication development (Tchernichovski, 2001). Tchernichovski et al (2001) took advantage of the sensory phase of model acquisition in the zebra finch, which overlaps with the period of motor development of learned vocalization, and performed an experiment. It would otherwise be difficult to distinguish between the learned and the innate component of developing sounds. When conducting the experiment, untutored subsong was recorded and then the birds were trained, starting on day 43 after hatching. A plastic model was used as the “tutor” playing the untutored subsong. As a result of testing, training birds with a model song induced an abrupt increase of song feature diversity by the second day of training. In 29 out of 40 birds trained, feature diversity increased above the upper confidence interval. This signifies higher temporal stability, and higher tonality basically meaning sounds became more structured. Birds that were exposed with a high pitched sound were heard producing a higher-pitched sound compared to the birds who were exposed to lower pitch sounds as early as day 2 of training. This indicates that

early training-induced changes in the acoustic structure were due to vocal learning. Results concluded that zebra finches can imitate the song syllables that they first hear during the sensitive period of local learning. This can infer that the tone of the zebra finches depend on the tone of the mentor. No matter if it's a high tone or low tone, infant zebra finches will be able to develop an almost identical song.

Conclusion & Implications

This literature review examines the potential benefits that studying zebra finches has on the development and understanding of speech and language in humans. The comparative studies done on humans and songbirds is an important part of researching the development of communication for both species which has allowed researchers to develop the idea of social interactions and communication. Songbirds learn to vocalize by imitating an adult male tutor, usually their father. Songbirds share the vocal learning trait with humans, where it provides the basis for speech and language acquisition. Among other mammals, there is evidence of vocal learning in cetaceans, bats (Boughman 1998; Deecke et al. 2000; Knornschild et al. 2010), and possibly elephants (Poole et al. 2005), but no substantiated reports of vocal learning in other mammals, including rodents (Mahrt et al. 2013), making avian species the only tractable organisms for studying mechanisms of vocal learning (Mello, 2014)

Social interactions and feedback from an adult mentor or tutor impact the memorization and clarity during speech development. Effective interactions and active participation in the beginning development of speech and songs/calls may be critical to both species (Kuhl, 2003).

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