Detecting the rhythmic temporal patterning of language: Infants' neural, physiological, and behavioral sensitivity

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A young infant's sensitivity to syllabic rhythm at around 1-1.5 Hz in both speech and sign is hypothesized to be a core language acquisition mechanism enabling the segmentation and categorization of the continuous language stream into discrete phonetic-syllabic units (Baker et al., 2006; Petitto et al., 1991; 2001; 2004; 2016). The brain's superior temporal gyrus (STG) is thought to be a key neural site driving this peak sensitivity (Petitto, 2007; Petitto et al., 2000; 2012). At the psychophysiological level, we hypothesize that the infant's sensitivity to linguistic rhythmicity should also trigger an emotional arousal that sustains the attentional and engagement behavior necessary for language acquisition. Still unknown, is whether infants are initially predisposed to be sensitive to syllabic rhythm *or* whether this sensitivity arises from language experience? Further, nothing is known about how neural activity, autonomic nervous system changes, and behavior are linked when human infants encounter the language signal. As a basic science component of our team's creation of RAVE discussed in this symposium (the Robot-AVatar thermal-Enhanced learning tool), discovery of both the language units to which babies have peaked sensitivity and the nature of the child's emotional arousal and attention in the presence of these language units provides new understanding of human language acquisition and establishes a computational foundation for programming RAVE to "know" when to start a conversational interaction with the baby because it is interested (attentive, and "ready to learn"), and when to cease.

Methods: 6-month-old *hearing* babies (N = 9), no sign language experience, viewed a video recording of meaningless but well-formed phonetic-syllabic units in signed language (SL) and identical syllabic information in point-light scenes (PL), which are stripped of surface phonological features but maintain global syllabic rhythms, while undergoing fNIRS neuroimaging, thermal IR imaging, and eye-tracking (all time-locked; block design, 4 conditions: SL syllable at 1.5Hz; PL syllable at 0.5Hz; 1.5Hz; 3.0Hz).

Predictions: If hearing babies (no sign) exhibit a peaked sensitivity to syllabic rhythm in *visual signed* language, then it provides evidence for a specific and amodal sensitivity to linguistic rhythms at 1-1.5Hz near the beginning of life that may constitute the key segmentation mechanism in early language acquisition, as indicated by (a) left hemisphere lateralization of neural activity for 1-1.5Hz, (b) differential participation of the autonomic nervous system (increases in parasympathetic activity), (c) increased looking time.

Results. Analyses show distinct neural and psychophysiological profiles associated with each condition, suggesting that infant brains are initially sensitive to distinct rhythmic-temporal patterns of syllables: SL 1.5 and PL 1.5 elicited stronger HbO changes in the left hemisphere compared to the right. Thermal IR results align: SL 1.5 elicited peaked parasympathetic activity indicating emotional engagement and attention (Manini et al., 2013).

Our findings add to the body of findings that suggest the existence of a core language acquisition mechanism linked to specific linguistic rhythmic-temporal patterning irrespective of modality, and provide key computational information on which to build rudimentary contingent social interaction and conversation into our innovative RAVE learning tool.