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A study of vocal non-linearities in Humpback whale songs: from production mechanisms to acoustic analysis

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Mammalian vocal production often includes non-linear sounds, including deterministic chaos and frequency jumps. These types of sounds are consistent with generation by a non-linear mechanism. In this study, we give qualitative descriptions and quantitative analyses of non-linearities in the song repertoire of humpback whales to provide more insight into the potential communication functions and underlying production mechanisms of these features. A low-dimensional biomechanical modeling of the whale's U-fold (vocal folds homolog) is used to relate specific vocal mechanisms to non-linear vocal features. Frequency jumps were found to result more often from near-formant source-filter interactions, whereas deterministic chaos depends mainly on source parameters, supported by the high subglottal pressure produced by humpback whales. A computer algorithm was used to search automatically through recordings of living humpback whales for occurrences of vocal non-linearities. Temporal distributions of non-linearities were assessed within sound units, and between different songs. The anatomical production sources of vocal non-linearities and the communication context of their occurrences in recordings are discussed. Our results show that vocal non-linearities may be a communication strategy that conveys information about the whale's body size and physical fitness, and thus may an important component of humpback whale songs.