

A theoretical account of whale song syntax: A new perspective for understanding human language structure

Cutler Cannon

Abstract. It is a common belief among linguists that the use of language is a species-specific phenomenon belonging only to humans. However, there is no doubt that there are non-human communication systems within the animal kingdom that are amazingly complex and share certain properties with human language (Berwick et al. 2011). The current paper – adapted from a more comprehensive undergraduate thesis – calls to attention the intricacy of one such system used among humpback whales (*Megaptera novaeangliae*). Recent findings by biologists and acousticians have uncovered an unpredictable pattern of bidirectional egressive and ingressive sounds in whale songs, leading to questions about song function and the presence of hierarchical structure akin to human language (Mercado & Perazio, 2021). While no conclusions have been unanimously agreed upon, whale song ‘syntax’ has the potential to remedy deficiencies in modern linguistic theory and provide insight into human communication. Drawing from recent literature about animal communication at large, whale singing behavior, and bidirectional sound production, I propose a theoretical, two-channel mechanism for the acoustic and structural nature of whale song. Using the two-channel mechanism, I further present a catalog of possibilities surrounding the potential for whale song compositionality to establish parallels with human language and ultimately argue a structural context for issues surrounding the modeling of paralinguistic computation, parentheticals, and syntactic amalgams.

Keywords. linguistics; syntax; animal communication; evolution; language science

1. An introduction to communication. Human language relies not only on semantics but also on structure. Beecher (2021) argues that animal communication systems have limited semanticity due to their small repertoire of vocalizations representing objects (≤ 25). However, he asserts that these limitations are natural rather than cognitive or production-related constraints. Beecher addresses the Principle of Compositionality, highlighting how humans can express novel constructions by combining phonemic units into meaningful and syntactically structured larger units. Contrary to studied animal communication systems, human language exhibits both semanticity *and* productivity. However, this paper aims to explore how phenomena like whale communication can provide resolve for discrepancies in modern syntactic theory. Before delving into the theoretical utility of whale song, I will briefly examine current understandings of communication theory and evolution.

1.1. PHONOLOGICAL STRUCTURE WITHOUT MEANING. Birdsong serves as a point of contention when comparing animal communication to human language. Unlike other animals, songbirds exhibit vocal learning, making them a unique taxon (Beecher 2021). While other animals produce vocalizations through instinct, development, or genetics, songbirds learn their vocalizations similarly to how humans learn language (Bolhuis et al. 2010). Researchers have found that songbirds possess a phonological repertoire and can create up to ten different song constructions (Beecher 2021). This raises the question of whether birdsong resembles a simple form of language. However, despite having vocal learning and a complex vocal repertoire, songbirds do not rearrange their syllables to convey different meanings. Consequently, birdsong is not considered a simple language, but its structural significance is still debated. Notably, the

hierarchical organization of birdsong bears a resemblance to the hierarchical structure of syntax trees (Figure 1), leading to arguments in favor of birdsong as a rudimentary form of language (Berwick et al. 2011).

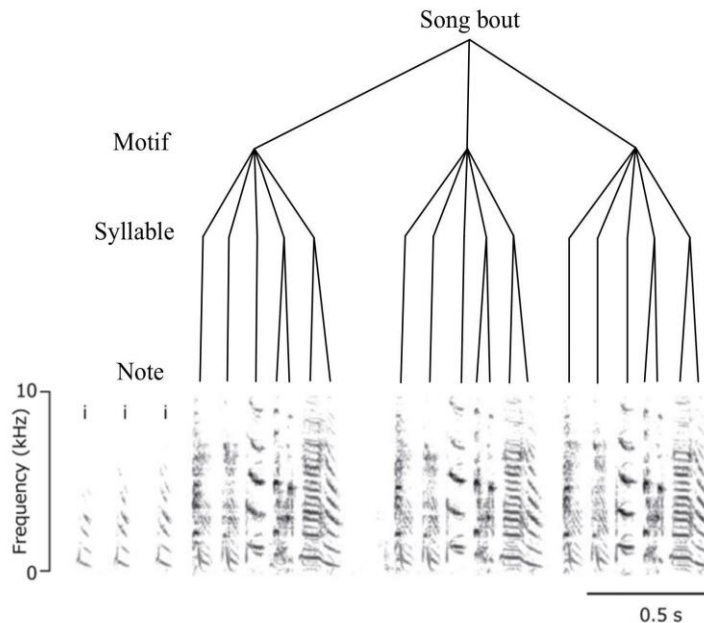


Figure 1. The structure of birdsong

However, despite the structural similarities observed in the syntax of birdsong and human language, it is argued that songbirds lack the ability to use this structure to represent different objects in space (van Heijningen et al. 2009). Unlike human language, where words are combined to convey propositional meanings, songbirds do not utilize their songs to communicate combinatory meanings (Beecher 2021). Specifically, birdsongs are described as a constrained type of finite-state automation, lacking lexical items or “words” that can be categorized (e.g., verbs, determiners, etc.) and hierarchically combined infinitely to generate new meanings. While birdsong may exhibit structural complexity and possess a form of phonological syntax, it does not demonstrate productivity and does not adhere to the Principle of Compositionality (Berwick et al. 2011).

1.2. MEANING WITHOUT PHONOLOGICAL STRUCTURE. Crist (2004) puts forth a compelling argument regarding the honey bee waggle dance,¹ suggesting that it exhibits several characteristics of human language, such as being rule-governed, complex, stable yet dynamic, symbolic, and performative. Notably, honey bees can combine two or three elements, such as orientation, speed, and enthusiasm, to convey an amalgamated meaning without the need for syntax (Riley et al. 2005). However, unlike birdsong, the honey bee waggle dance is believed to be genetically predetermined rather than learned. Additionally, unlike human language, it lacks semanticity, as the dance lacks syntactic constraints associated with lexical items that determine and influence meaning (Anderson 2004). Consequently, the honey bee dance “language” lacks

¹ This paper adopts the spelling of *honey bee*, as opposed to *honeybee*, per the Entomological Society of America.

the phonological complexity of human language, which involves both structure and meaning (Chomsky & Berwick 2016).

1.3. WHAT IS LANGUAGE? When discussing birdsong, which serves purposes like territorial marking, mate attraction, and other “expressive” actions without clear syntactic structure, it can be viewed as a form of Type E(xpression) structure (Berwick et al. 2011; Miyagawa et al. 2013). In contrast, non-primate communication systems contain Type L(exical) structures, where predicates are accompanied by one or more “arguments” (e.g., speed and direction) as seen in the honey bee waggle dance (Riley et al. 2005). While Type E and L structures individually possess meaning (L) and complexity (E), they do not have the capacity on their own, unlike human language, to generate recursively infinite structures (Berwick et al. 2011). In human language, Type E structures represent a limited number of functional elements without independent status (e.g., -ed or question markers), whereas Type L structures represent independent elements (e.g., words) without immediate functional connections to one another. The interplay between these two systems in human language implies a *duality of semantics* (Miyagawa et al. 2013). Consider the Figure 2 below for the sentence *Billy did sing [the] songs*:

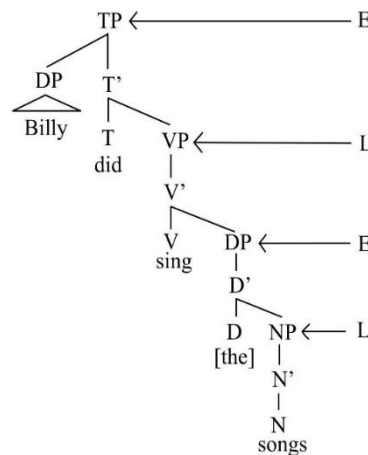


Figure 2. E/L hierarchy for *Billy did sing [the] songs*

Assigning a clear definition to words like *did* (tense-marker) and *the* (determiner) is challenging compared to words in other word classes, indicating that they belong to the expression structure (Miyagawa et al. 2013). This observation suggests that human language is composed of E/L hierarchies that combine Type E and Type L structures (Figure 2). The following example shows the inability to grammatically construct a structure containing purely lexical elements (lacking the E structure *and*), further supporting the presence of E/L hierarchies in human language.

(1) Sing write songs.*

Therefore, according to Miyagawa et al. (2013), the evolution of hierarchical structures in human language can be traced back to the independent structures observed in non-human animal communication systems, as discussed earlier. The E/L theory of evolutionary linguistics seeks to

elucidate the distinctions between human language and other systems and shed light on the emergence of the Principle of Compositionality. However, an intriguing question remains: do non-human communication systems possess structural organizations that could offer novel insights into our understanding of human language? Perhaps the answers lie beneath the surface of the water.

2. The anomaly of whale song. Now that the previous sections have established awareness of the big questions surrounding human language evolution, structure, and non-human animal communication, the discussion of whale song becomes especially relevant. Because – while the bee waggle dance, songbird songs, and non-human primates have been the focus of an extensive amount of literature, dating back to the 1940s and 50s – humpback whale (*Megaptera novaeangliae*) songs have only recently been examined from a syntactic perspective. Previous research spanning five decades has established that humpback whale songs are primarily produced by males, although females and juveniles are also known to produce sounds (Janik 2009). Notably, these songs exhibit implications both within and between sexes. Despite being one of the few mammals known to sing, the role of song in humpback whales, specifically in terms of sexual selection, remains poorly understood. While it is often assumed that humpback whale songs serve the purpose of attracting females for reproductive purposes, it has been observed that whale songs also mediate male-male interactions, as evidenced by the formation of two-singer dyads, changes in presentation, song evenness, and the rate at which phrase types vary (Cholewiak et al. 2018; Darling & Bérubé 2006). These intersexual interactions raise the possibility of communication beyond reproduction. Is it possible that their songs entail more than simple learned phonological syntax (as seen in bird songs) or innate genetic programming (as observed in bee dances), existing beyond the assumptions related to mate attraction?

2.1. STRUCTURE OF WHALE SONG. Roughly 50 years ago, Payne and McVay (1971) first described the acoustic performances of whales as “songs,” but their function is a mystery. Nevertheless, their structures have been studied extensively. It has been observed that whales sing continuously, without distinct pauses, for extended durations of 20+ hours, and some individuals have been known to sing for up to 70 hours (Payne & McVay 1971). Recently, researchers have undertaken analyses of these song sessions to investigate potential underlying syntax, with the aim of expanding our understanding of mammalian communication beyond the confines of human language. Whale biologist Jenny Allen argues that little is known about rules governing non-human mammalian vocalizations and that humpback whale song can provide a model for a better understanding of such phenomena (Allen et al. 2019). She argues that whales produce songs in a stereotyped, nested multi-level hierarchy where *units* (or individual sounds) are arranged in a stereotyped pattern to comprise a *phrase* (a collection of units), where phrases then repeat to make a *theme*, and a string of four to seven themes make up a *song*. Yet, this argument is not entirely foreign. As noticed in Figure 3, humpback whale songs share a phonological structure resemblant to birdsong.

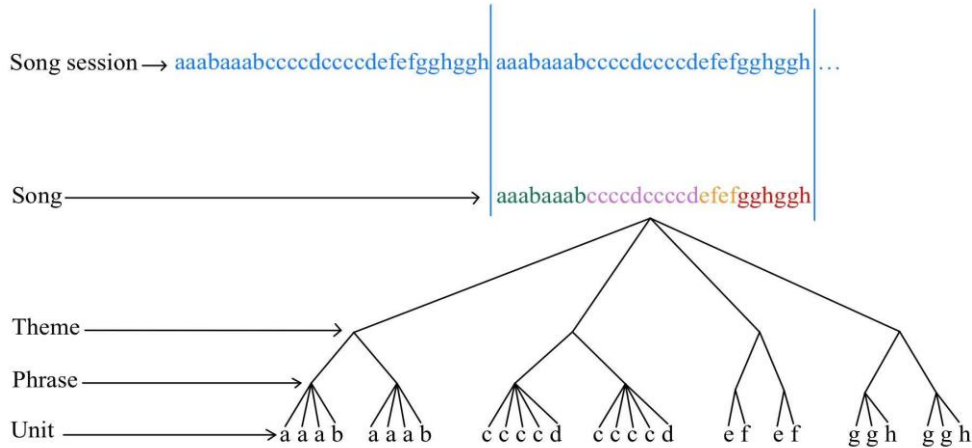


Figure 3. ‘Hierarchical’ structure of whale song

In Figure 3, I employ the methodology commonly found in the literature by using letters to represent units and constructing a hierarchical representation of the proposed structure of whale song. Like the proposals of Allen et al. (2019) and numerous others, the categorical arrangement of song sessions has led many researchers to draw comparisons to human syntax and its hierarchical nature, concluding that whale song is also structurally hierarchical (Cholewiak et al. 2018; Payne & McVay 1971).

2.2. CULTURE OF WHALE SONG. It is noted that whales – unlike birds – do not use a fixed repertoire of sounds (Cholewiak et al. 2013; Mercado & Handel 2012). In a whale pod, all male whales will typically adopt one song pattern, but it is not uncommon for the song to vary in structure over a same-year period. These variations are argued to be adopted through horizontal social learning, where unit-level and theme-level changes have been recorded (Garland & McGregor 2020). The question of *why* then becomes relevant, as this suggests that song production is, in fact, a conscious phenomenon that occurs outside of simple reflex. Namely, I suggest that whale song communication exists with a complexity outside of what is observed in birds or bees. Whales actively engage with song variations – they do not simply listen to the overarching song patterns but instead recognize and pay attention to individual unit shifts enough to adopt the shifts themselves. Because there is no evidence to support a knowledge of whale cognition, I do not believe it is possible to understand whale song to the same extent that we understand (through experience) the human process of thought and language.

2.3. THE STATE OF WHALE SONG ANALYSIS. Returning to structure, Mercado and Perazio (2021) argue that even if whale songs were hierarchically structured in the ways proposed by others in the field, this would not entail that whale songs are compositionally meaningful. While whale song does – with the evidence that we *do* have – differ from human language in the sense that it is not compositionally organized, I propose that there are parallels to be made on how human language also contains non-compositional hierarchal organization. Consider Figure 4.²

² Adapted from Heffner & Slevc 2015: Fig. 1 .

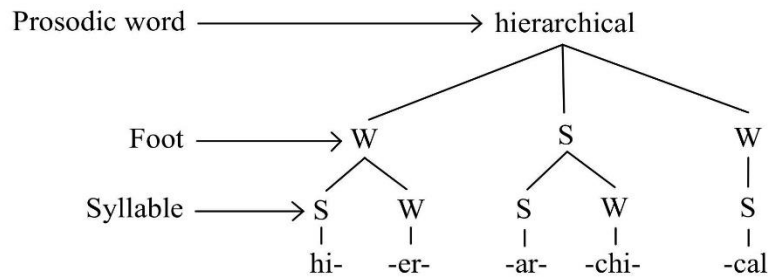


Figure 4. Prosodic structure of *hierarchical*

As a prosodic structure, Figure 4 demonstrates that a word's phonological production can be hierarchically structured. Namely, that a *prosodic word* is pronounced by one or more weakly (W) or strongly (S) pronounced *feet* comprised of weakly or strongly pronounced *syllables*. As with the case above, the pronunciation of *hierarchical* can be modeled to show that, for example, *hi-* and *-er-* are nested within one of the three prosodic feet that make up the word. However, when contrasted with a syntax tree that is hierarchical and compositional, it is noted that an individual syllable such as *-chi-* does not hold meaning in the same way that a lexeme does. This demonstrates that while a word may hierarchically contain entities such as syllables, the prosodic construction of a word does not entail compositionality nor recursion in the same way as human language syntax. Hence, prosodic structures prove that even human language can be modeled similarly to bird and whale song, although the emphasis is on phonological organization rather than syntactic structure.

Similarly, Mercado and Handel (2012) do not contend that whales cannot produce compositionally hierarchical structures, but they sidestep debates surrounding hierarchical organization and assert that whale song productions can be organized and analyzed acoustically. Mercado and Handel (2012) argue that song variation is due to two things – the dive cycle and internal recirculation of air – rather than conscious syntactic computation. Nevertheless, it is important to note that the proposed hierarchical structure of whale song has never been empirically tested, and it is challenging to envision a method to obtain such evidence. Instead, Mercado and Handel (2012) propose that whale song is *heterarchically* structured in the sense that two (or more) physiological cycles interact to generate the structured acoustic qualities of song patterns. However, with focus on the argument that structure comes from a combinatorial interaction of acoustics, not much emphasis is given to the possibility of hierarchical structure. This does not mean that hierarchical structure within whale songs doesn't exist, but that it's simply undeterminable given our current technologies and capabilities. It is also possible that perhaps whale song is simply conducted and perceived in ways unconsidered by humans. Perhaps whales are using depth to consciously modulate songs rather than variation being a mindless consequence; perhaps the use of air recirculation is also a conscious tactic of modulation. Building off the proposals offered by Mercado and Handel (2012), I take particular interest in the idea of air recirculation and will explore this phenomenon and its possible implications.

3. Physiology of whale song production. Before much can be said about the syntactic potential of whale song, it is important to establish a physiological differentiation between whale and human respiratory systems and resultant sound production.

In human speech, air from the lungs passes through the vocal cords, creating vibrations responsible for sound production and recognition. However, unlike the ear of the humpback whale, the human ear is not evolved for underwater hearing where humpback whales spend their time. Furthermore, contrary to what one may assume, air does not escape from the whale's body during sound production as it does during human speech (Mercado & Perazio 2021). Instead, the vibrations yielded from their U-shaped vocal cords cause vibrations within the tissues of the laryngeal sac, a specialized organ within whale anatomy, making egressive sounds. These vibrations transfer through the overlying blubber and skin and eventually into the water, experiencing minimal transmission loss due to the density similarity between tissue and water (Damien et al. 2019). The air residing in the laryngeal sac then recirculates back into the lungs, resulting in ingressive sounds. This production of both egressive and ingressive sound is referenced by what Mercado and Handel (2012) call "bidirectional sound production" and "internal recirculation of air." While humans can produce ingressive sounds (e.g., whistling via inhalation), human language is primarily made up of egressive sounds.

Furthermore, Humpback whales appear capable of confining air into various chambers of the respiratory system because of the multiple valve sites along the respiratory tract. Given that the volume of at least one of these chambers – the laryngeal sac – is controlled by voluntary muscle contraction, this gives reason to believe that whales are capable of controlling their buoyancy independently of, or in addition to, the effects of ambient air pressure exerted in that chamber (Damien et al. 2019). This conscious control could relate to the whales' use of depth as a measure of sound production. However, this possibility is wildly speculative and not extensively researched, especially in the specific context of song production. Most research concerning dive cycle centers around behavioral questions as opposed to those related to the physiology of sound production – this provides another avenue of rich research yet to be explored. Still, because this paper does not provide empirical data, my purpose will not be to argue the specifics related to the relationship of dive depth to phonological impact. Instead, I will be developing an argument pertaining specifically to the use of bidirectional sound production in whales.

4. Relevance for linguistics and human language. If whale song has demonstrated complexity extending past birdsong through song variation and the use of egressive *and* ingressive sounds, what could this mean for the study of other animal communication systems and human language? Could it provide insight into the origins of language in an evolutionary sense? Could a developed familiarity with non-primate mammalian communication provide a platform by which mysteries of human syntax can be analyzed from a different viewpoint, allowing for a better understanding of human language? These are important questions to consider, instead of adopting a view that whale song is unuseful to study linguistically. Because ingressive and egressive sounds are produced unpredictably in whale song sessions, it is possible that sound type could serve as a determiner of its function, similar to how different phonological categories in human language serve various functions in human speech (e.g., vowel classification). One suggestion is that ingressive and egressive sounds provide different information synthesized to yield a composite meaning for immediate whale communities. Alternatively, egressive and ingressive sounds may be utilized to communicate with different target communities – like those closer and those further away – since egressive and ingressive sounds occupy different frequencies (Mercado & Perazio 2021).

Some argue that the presence of unchanged songs within a population is indicative of a lack of cultural transmission. However, considering common phrases used in social settings, such as “How are you? What are you doing?” It’s entirely possible for these statements to be repeated verbatim over time in different regions, even without direct social interactions between said regions. But this does not mean that slang and other variations in dialect and vocabulary fail to propagate through human populations via cultural transmission. I propose that both original constructions and emerging variations can coexist. In a similar manner, whales may also engage in communicative practice where some songs remain fixed as shared elements, while others are more flexible and subject to variation through cultural transmission. Just as human populations can maintain certain commonalities while allowing for modification, it is plausible that whales exhibit a similar dynamic in their song repertoire. Thus, the presence of unchanged songs in whale populations does not necessarily negate the possibility of cultural transmission and variation within their communicative behaviors.

Again, there is no way to know exactly how or why whale songs operate functionally, but perhaps there is a ‘catalog’ of different possibilities to explore. Instead of jumping to the conclusion that whale singing behavior is obviously not a case of cultural/social transmission, I am not going to take for granted the complex structure that whale songs exhibit outside of what is seen in avian song. Based on the acoustic properties of ingressive and egressive sounds, as well as the mystery as to why whales utilize both in their songs, I propose that – in interest of the possibility that whale songs are functional in some way outside of reproduction – whales may be using two channels of communication. In doing so, whales may be providing and processing two separate inputs that can be interpreted together (or separately, if, say, the purpose of one is to communicate to proximal communities and the other is used to communicate to distant ones) to yield meaning.

5. Parallelisms of song and language structure. Utilizing a two-channel communication framework to examine whale song, I will outline three possible scenarios. In the first scenario, I will draw a comparison where whale song lacks compositional structure, similar to birdsong, and is solely phonologically structured. In the second scenario, I will present a parallel where whale song exhibits compositional structure exclusively in the egressive channel, akin to human speech. Lastly, in the third and potentially most intriguing scenario, I will argue that whale song displays compositional structure in both the egressive and ingressive channels, drawing parallels to human language and syntax.

5.1. WHALE SONG IS MEANINGLESS. Taking a pessimistic and pragmatic standpoint, I align with the speculation that whale song, akin to bird song, is primarily phonologically structured and lacks inherent meaning. It is likely a result of genetic predisposition and reflex, rendering it non-compositional. However, I aim to illustrate that humans also exhibit a similar phenomenon of bidirectional sound production in a non-compositional manner. Specifically, I draw attention to the acoustic resemblance between whale song and snoring. Characterized by the alternation between pulsive and tonal sounds, snoring is rhythmic and recognizable but lacks meaningful or compositional elements. Although there may not be substantial depth for analysis, as the productions themselves lack inherent meaning, this parallelism is significant because it highlights that if whale song is indeed devoid of meaning, the occurrence of bidirectional sound production still manifests in humans.

5.2. WHALE SONG IS MEANINGFUL. The upcoming arguments draw from the acoustic assessments presented by Mercado and Perazio (2021), which propose the possibility of whales utilizing two communication channels for the creative transmission of information. It is worth noting, however, that Mercado and Perazio (2021) argue against the creative processes in whales, favoring genetic predisposition and imitation. Conversely, numerous researchers, including Allen et al. (2019), contend that whale song is a result of cultural transmission and social interaction. Considering these perspectives, my arguments will aim to merge the acoustic properties of whale song with the notion that they may indeed be products of creativity and compositionality.

5.2.1. EGRESSIVE COMPOSITIONALITY. Under this first possibility where whale song is considered meaningful, I argue that if only the egressive channel of whale song exhibits compositionality and syntactic structure like egressive sounds in human speech, it does not diminish the significance of the ingressive channel. For instance, while the egressive channel carries the compositional transmission of information, the sounds produced in the ingressive channel could serve to indicate characteristics of the egressive channel's contents, such as importance and context. This concept draws a parallel to paralinguistic communication in human language. Paralinguistic communication encapsulates many non-verbal techniques, including facial expressions, body language, tone, pitch, and even silence (Austin 19). Naturally, it can be imagined how paralinguistic communication has much to do with human language and communication. It gives insight into how while aspects of human communication are syntactic and compositional, non-lexical qualities are not (Mehrabian 1972). This suggests that human language is so much more than the words used to construct it. Further, when interacting and interpreting language, humans utilize and interpret multiple channels of communication to extrapolate overall meaning. Namely, if a situation were to arise where someone said, "Sarah is telling the truth," while shaking their head, the perceiver would be tempted to interpret the exchange as a negation of what is said: Sarah is *NOT* telling the truth. Therefore, if only one channel of whale song is compositional while the other is not, I argue that the same phenomenon is demonstrated by human communication through paralinguistic communication.

5.2.2. EGRESSIVE AND INGRESSIVE COMPOSITIONALITY. Lastly, an even more radical – but very intriguing – position considers the possibility of compositionality in *both* channels. Under this belief, I will establish three cases in which two-channel compositionality can provide explanations for other phenomena of human language currently unexplained by modern syntactic theory. Specifically, this section will address gaps in theory and offer syntactic reconfigurations to represent modifiers, parentheticals, and syntactic amalgams.

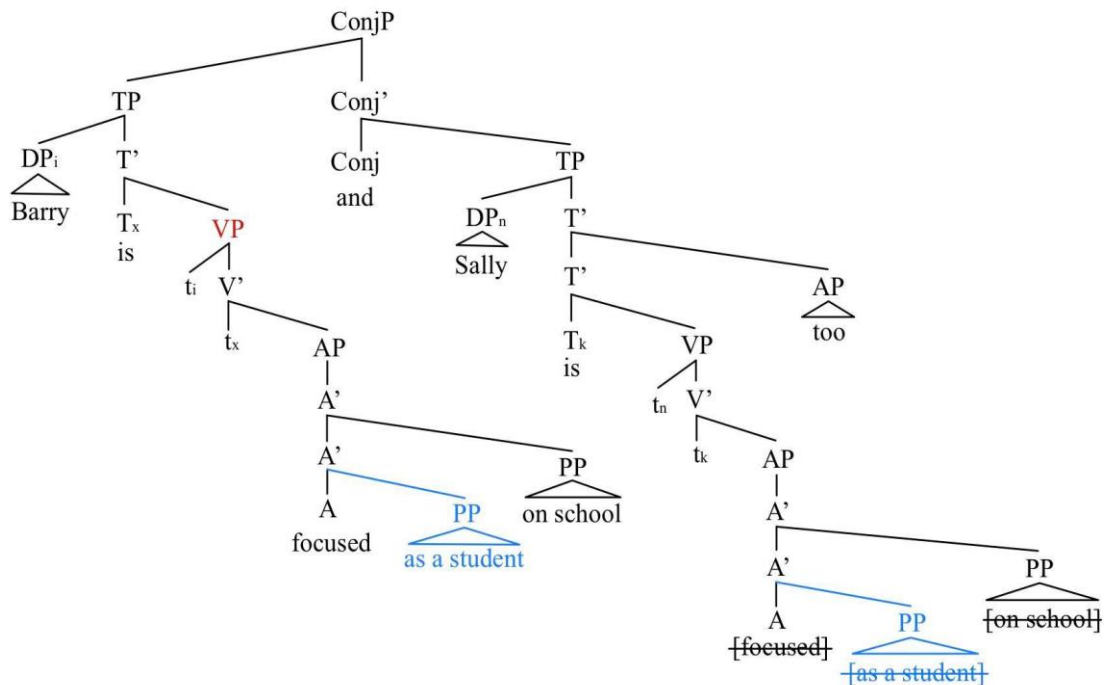
5.2.2.1. MODIFIERS. In human language grammar, modifiers are lexical words or phrases that restrict or add to the sense of head nouns or NPs. I argue, however, that restrictive and non-restrictive modifiers have different syntactic qualities and use of a second channel. To introduce this perspective, I will analyze the points Heim and Kratzer (1998) addressed regarding these two classes of modifiers. Consider the examples below and the following syntax tree:

5.2.2.2. PARENTHETICALS WITH VP ELLIPSIS. Expounding on the phenomenon of non-restrictive modifiers – a subset of parenthetical – parentheticals at-large have presented an interesting phenomenon for both syntacticians and semanticists to grapple with, as it appears they function in a sometimes-unpredictable manner. In Standard American English, it is not uncommon for a person to utilize parentheticals in their speech to insert an explanatory or qualifying word, clause, or sentence. This subsection will specifically address the phenomenon of VP ellipsis, the ways in which modern syntactic models fail to represent it, and how these problems can be resolved with the two-channel method. VP ellipsis refers to a phenomenon and type of anaphora in which a verb phrase is excluded, or elided, from a syntactic construction as long as its antecedent presides within the same linguistic context. Consider below.

(4) Barry is focused on school, and Sally is too.

In the above example, the VP in [Sally is [VP] too] becomes the target for the VP in the antecedent and thus is elided and interpreted without externalized repetition in speech. VP ellipsis, however, poses a problem for parenthetical placement in the syntax, because Potts (2002) suggests that *as*-parentheticals attach where they are interpreted and pronounced. Consider the sentence below, adapted from (4), and imagine a world in which Barry is a student and Sally is a professor:

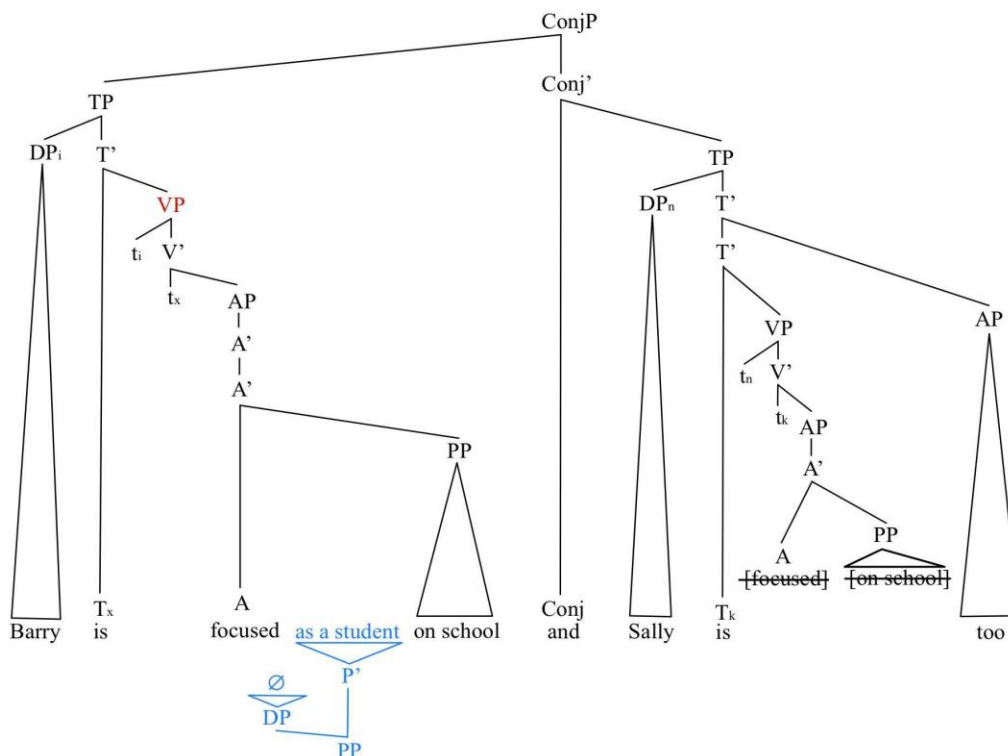
(5) Barry is focused, as a student, on school, and Sally is focused, as a student, on school too.



In the sentence structure for Example 5, the parenthetical is nested within the VP with no other possibilities of higher attachment (such as T') while still maintaining word order. Additionally, the tree contains an elided VP, which makes the syntax problematic considering the proposed world where Sally is a professor, not a student, and the fact that a parenthetical separates a head from its complement. This problem, unreconcilable using modern syntactic

analysis, can be rectified if assessed through the two-channel method. Consider the two-channel structure of Example 6 below:

- (6) Barry is focused, as a student, on school, and Sally is ~~focused on school~~ too.



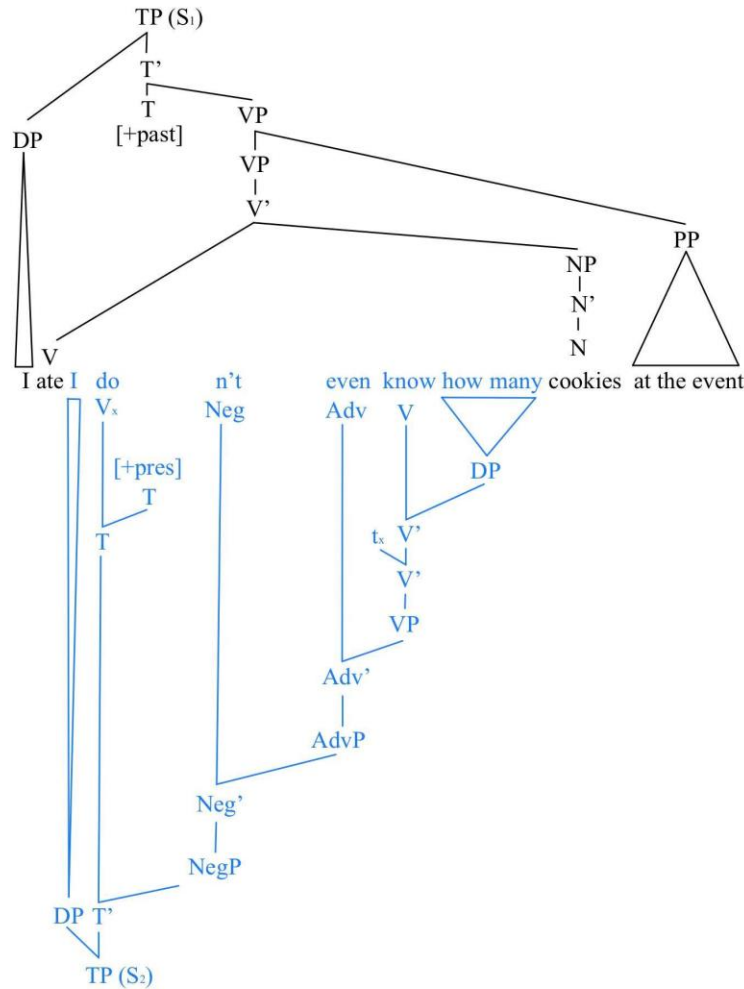
It is important to note that there are characteristics to support that parentheticals are processed differently – on a different channel – than the rest of the sentence that contains them. This is because research supports that parentheticals occur between prosodic gaps, occupy different speech rates, do not carry primary stress, and have low pitch range in comparison to the main clause in which the parenthetical is inserted (Dehé & Wichmann 2010; Dickerson 1999). Thus, I conclude that it is not completely unreasonable to model syntax in the way I have done in Example 6. Specifically, the structure is comprised of a DP that is containing of the parenthetical but separate from the main ConjP, *Barry is focused on school and Sally is too*. The DP in the second channel is occupied by a \emptyset to show that it will refer to some DP, such as *Barry*, to show contrastive focus depending on discourse rules. The most important property of this construction, however, is related to the elided VP. Previously, in Example 5, the parenthetical that separated the head from its complement was forced to elide, yielding a semantically incorrect interpretation given the conditions of the world previously established. In the new construction, however, the parenthetical is no longer nested within the VP, allowing for it to elide freely without the consequence of incorrectly interpreting it within the elided VP of the conjoined TP, *Sally is too*.

5.2.2.3. SYNTACTIC AMALGAMS. First documented and discovered by Lakoff (1974), syntactic amalgams are nonstandard grammatical patterns that contain two or more contiguous or overlapping syntactic sequences that cannot otherwise be combined, allowing for multiple propositions to be presented in a singular sentence with parenthetical-like constructions (Brenier & Michaelis 2005; Guimarães Miranda 2004). Consider Example 7.

(7) I ate **I don't even know how many** cookies at the event.

It can be imagined and recalled how these sorts of constructions could be used and are not foreign to normal conversation. However, because syntactic amalgams are produced by an unusual merging of propositions, modern syntactic theories do not currently propose adequate methods for modeling these sorts of constructions. Instead, using the two-channel mechanism – where syntactic amalgams may be separated since they are made up of two distinct propositions – I offer the below structure for Example 7 to show a way that allows for a constituent to not be shared by two parents in the same channel.

(8)



Suppose whale song is compositional and meaningful both ingressively and egressively, which would mean that they are able to transmit different information along each channel. In that case, I thus offer a possibility for how human language can be analyzed similarly. If parentheticals were processed in a different channel, this would explain their prosodic differences and also allow for current insufficiencies in syntactic modeling to be solved. Further studies could investigate the neurolinguistic plausibility of two-channel communication, to determine whether different areas of the brain are activated when parentheticals are used.

6. Conclusion. Because of the unique acoustic properties of whale song, containing remarkable use of egressive and ingressive sounds, I have used this paper to present a two-channel mechanism that may exist in human cognition to parse together [or apart] semantic products from both linguistic and non-linguistic inputs. By applying this two-channel method to human communication, I could successfully discuss paralinguistic processing and propose possible solutions to current problems in modern syntactic theory concerning the modeling of parentheticals and syntactic amalgams. While further work must be done to better understand the biological relevance of two-channel communication, and how such a theory could be more formally and widely introduced into the study of syntax, this paper serves as a steppingstone towards better conceptualizing how animal communication may provide tools for analyzing human language structure.

References

- Allen, Jenny A, Ellen Garland, Rebecca Dunlop & Michael Noad. 2019. Network analysis reveals underlying syntactic features in a vocally learnt mammalian display, humpback whale song. *Proceedings of the Royal Society B* 286. 1917. <https://doi.org/10.1098/rspb.2019.2014>.
- Anderson, Stephen R. 2004. *Doctor Dolittle's delusion: Animals and the uniqueness of human language*. New Haven, CT: Yale University Press.
- Austin, William M. 1965. Some social aspects of paralanguage. *Canadian Journal of Linguistics* 11(1). 31–39. <https://doi.org/10.1017/S0008413100005703>.
- Beecher, Michael D. 2021. Why are no animal communication systems simple languages? *Frontiers in Psychology* 12. <https://doi.org/10.3389/fpsyg.2021.602635>.
- Berwick, Robert C., Kazuo Okanoya, Gabriel Beckers & Johan Bolhuis. 2011. Songs to syntax: The linguistics of birdsong. *Trends in Cognitive Sciences* 15(3). 113–121. <https://doi.org/10.1016/j.tics.2011.01.002>.
- Bolhuis, Johan J., Kazuo Okanoya & Constance Scharff. 2010. Twitterrevolution: converging mechanisms in birdsong and human speech. *Nature Reviews* 11(11). 747–759. <https://doi.org/10.1038/nrn2931>.
- Brenier, Jason M. & Laura Michaelis. 2005. Optimization via syntactic amalgam: syntax-prosody mismatch and copula doubling. *Corpus Linguistics and Linguistic Theory* 1(1). 45–88. <https://doi.org/10.1515/cllt.2005.1.1.45>.
- Broughton, W. B. 1963. Method in bio-acoustic terminology. In René Busnel (eds.), *Acoustic behavior of animals*, 3–24. Boston: Elsevier Publishing Company.
- Bruni, Luis E. & Franco Giorgi. 2015. Towards a heterarchical approach to biology and cognition. *Progress in Biophysics and Molecular Biology* 119(3). 481–492. <https://doi.org/10.1016/j.pbiomolbio.2015.07.005>.
- Catchpole, Clive K. & Peter J. B. Slater. 2008. *Bird song: Biological themes and variations* (2nd ed.). Cambridge, UK: Cambridge University Press.
- Cholewaik, Danielle, Salvatore Cerchio, Jeff K. Jacobsen, Jorge Urbán-R & Christopher W. Clark. 2018. Songbird dynamics under the sea: acoustic interactions between humpback whales suggest song mediates male interactions. *Royal Society Open Science* 5(2). 171298. <https://doi.org/10.1098/rsos.171298>.
- Chomsky, Noam & Robert C. Berwick. 2016. *Why only us?* Cambridge, MA: MIT Press.
- Crist, Eileen. 2004. Can an insect speak? The case of the honey bee dance language. *Social Studies of Science* 34(1). 7–43. <https://doi.org/10.1177/030631270404061>.

- Damien, Juliette, Olivier Adam, Dorian Cazau, Paul White, Jeffrey T. Laitman & Joy S. Reidenberg. 2019. Anatomy and functional morphology of the Mysticete Rorqual Whale larynx: Phonation positions of the U-fold. *The Anatomical Record* 302(5). 703–717. <https://doi.org/10.1002/ar.24034>.
- Darling, James & Martine Bérubé. 2006. Interactions of singing humpback whales with other males. *Marine Mammal Science* 17(3). 570–584. <https://doi.org/10.1111/j.1748-7692.2001.tb01005.x>.
- Dehé, Nicole & Anne Wichmann. 2010. The multifunctionality of epistemic parentheticals in discourse. *Functions of Language* 17(1). 1-28. <https://doi.org/10.1075/foL.17.1.01deh>.
- Dickerson, Wayne. 1999. The sound and substance of conversational commentaries. In Lawrence F. Bouton (ed.), *Pragmatics and language learning* (Monograph Series 9), 163–172. Urbana, IL: University of Illinois Press. <http://hdl.handle.net/2027/inu.30000056056157>.
- Garland, Ellen & Peter McGregor. 2020. Cultural transmission, evolution, and revolution in vocal displays: Insights from bird and whale song. *Frontiers in Psychology* 11. <https://doi.org/10.3389/fpsyg.2020.544929>
- Guimarães Miranda, Maximiliano. 2004. Derivation and representation of syntactic amalgams. College Park, MD: University of Maryland dissertation.
- Heffner, Christopher & Robert Slevc. 2015. Prosodic structure as a parallel to musical structure. *Frontiers in Psychology* 6(94). <https://doi.org/10.3389/fpsyg.2015.01962>.
- Heim, Irene & Angelika Kratzer. 1998. *Semantics in Generative Grammar*. Oxford, UK: Blackwell Publishers.
- Janik, Vincent. 2009. Whale song. *Current Biology* 19(3). 109–111. <https://doi.org/10.1016/j.cub.2008.11.026>.
- Lakoff, George, 1974. *Syntactic amalgams*. *Chicago Linguistic Society (CLS)* 10. 321–344.
- Mehrabian, Albert, 1972. *Nonverbal communication*. New York, NY: Routledge.
- Mercado, Eduardo & Stephen Handel. 2012. Understanding the structure of humpback whale songs (L). *The Journal of the Acoustical Society of America* 132(5). 2947–2950. <https://doi.org/10.1121/1.4757643>.
- Mercado, Eduardo & Christina Perazio 2021. Similarities in composition and transformations of songs by humpback whales (*Megaptera novaeangliae*) over time and space. *Journal of Comparative Psychology* 135(1). 28–50. <https://doi.org/10.1037/com0000268>.
- Miyagawa, Shigeru, Robert Berwick & Kazuo Okanoya. 2013. The emergence of hierarchical structure in human language. *Frontiers in Psychology* 4(71). <https://doi.org/10.3389/fpsyg.2013.00071>.
- Payne, Roger & Scott McVay. 1971. Songs of humpback whales. *Science* 173(3997). 585–597. <https://doi.org/10.1126/science.173.3997.585>.
- Potts, Christopher. 2002. The syntax and semantics of *as*-parentheticals. *Natural Language & Linguistic Theory* 20(3). 623–289. <https://doi.org/10.1023/A:1015892718818>.
- Riley, Joseph R., Uwe Greggers, A. D. Smith, Don R. Reynolds & R. Menzel. 2005. The flight paths of honeybees recruited by the waggle dance. *Nature* 435. 205–207. <https://doi.org/10.1038/nature03526>.
- van Heijningen, Caroline, Jos de Visser, Willem Zuidema, & Carel ten Cate, 2009. Simple rules can explain discrimination of putative recursive syntactic structures by a songbird species. *Proceedings of the National Academy of Science* 106(48). 20538–20543. <https://doi.org/10.1073/pnas.0908113106>.