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Authors

Colbert-White, Erin

Beyer, Tim

Kuczaj, Stan

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Compositional Differences, Functional Similarities: A Linguistic Analysis of Private Speech from a Young Child and a Home-Reared African Grey Parrot (*Psittacus erithacus erithacus*)

Erin N. Colbert-White¹, Tim Beyer¹, and Stan A. Kuczaj II²

¹Department of Psychology, University of Puget Sound

²Department of Psychology, University of Southern Mississippi

Humans and other vocal-learning species engage in solo vocalizations. Such vocalizations in the human literature are referred to as private speech and have been hypothesized to play a role in vocal repertoire development both in humans and nonhumans, alike. The current study used corpus linguistics techniques to quantitatively and qualitatively compare the private speech of a two-year-old child and an enculturated, home-reared African Grey parrot to identify similarities and differences in the composition and function of their private speech. Both speakers exhibited previously documented human private speech functions, including sound- and word-play and repetitive practice of new words. The composition of the utterances, however, was different between the two speakers. The child's private speech contained a larger vocabulary, more frequent use of function words (i.e., prepositions, articles, pronouns, conjunctions) to string together ideas, and the use of multiple verb tenses. The cross-species finding that a home-reared parrot's private speech is similar in function—including evidence of play and possible intrinsically-motivated practice—to that of a language-learning child offers unique insights into the evolution of human language.

Keywords: African Grey parrot, comparative, language, linguistic analysis, private speech

構成の違いと機能の類似性：幼い子どもと家庭で飼育されているヨウムの私的発話の言語学的分析

ヒトや発声を学習する他の生物種は単独で発声を行う。ヒトの文献では、このような発声は私的発話と呼ばれ、ヒトでもヒト以外の種でも、発声のレパートリーの発達に役立っているという仮説が立てられている。本研究では、コーパス言語学の手法を用いて、2歳の子どもの、文化化され、家庭で飼育されているヨウムの私的発話を定量的・定性的に比較し、私的発話の構成と機能の類似点と相違点を明らかにした。両者とも、音遊びや単語遊び、新しい単語の反復練習など、これまでに報告されているヒトの私的発話機能を示した。しかし、発話の構成は両者で異なっていた。ヒトの子どもの私的発話にはより多くの語彙が含まれ、考えをつなぎ合わせるために機能語（前置詞、冠詞、代名詞、接続詞など）がより頻繁に使われ、複数の動詞の時制が使われた。家庭で飼育されているヨウムの私的発話は、遊びや内発的動機に基づく練習の証拠も含め、言語を学習する子どものものと機能的に類似しているという、種を超えて得られた知見は、ヒトの言語の進化に関する固有の洞察を提供する。

キーワード：ヨウム、比較、言語、言語分析、私的発話

Diferencias en composición, similitudes funcionales: un análisis lingüístico del habla privada de un niño pequeño y un loro gris africano criado en casa (*Psittacus erithacus erithacus*)

Los humanos y otras especies que aprenden vocalmente realizan vocalizaciones en solitario. En la literatura humana, estas vocalizaciones se denominan habla privada y se ha planteado la hipótesis de que desempeñan un papel en el desarrollo del repertorio vocal tanto en animales humanos como en no humanos. El presente estudio se utilizaron técnicas lingüísticas de corpus para comparar cuantitativa y cualitativamente el habla privada de un niño de dos años y un loro gris africano criado en casa, para identificar similitudes y diferencias en la composición y función del habla privada. Los dos participantes exhibieron funciones del habla privada humana previamente documentadas, incluidos juegos de sonidos y palabras y práctica repetitiva de nuevas palabras. La composición de las declaraciones, sin embargo, fue diferente entre los dos participantes. El habla privada del niño contenía un vocabulario más amplio y un uso más frecuente de palabras funcionales (es decir, preposiciones, artículos, pronombres, conjunciones) para unir ideas y el uso de múltiples tiempos verbales. El hallazgo comparativo entre especies de que el habla privada de un loro criado en casa tiene una función similar (incluidas evidencias de juego y una posible práctica intrínsecamente motivada) al de un niño que aprende un lenguaje ofrece ideas únicas sobre la evolución del lenguaje humano.

Palabras clave: loro gris africano, comparativo, lenguaje, análisis lingüístico, habla privada

Some vocal-learning species have been documented to vocalize while alone. In humans, this has been termed private speech¹. A robust literature illustrates the developmental trajectories of private speech in children (see Berk, 1992, and Winsler, 2009, for reviews). This literature describes compositional features and the presumed functions of private speech and confirms that private speech plays a role in human language development. The purpose of the current comparative case study is to identify parallels and distinctions in the private speech of two vocal-learning speech users, a home-reared African Grey parrot (*Psittacus erithacus*) and a two-year-old child. By dissecting both speakers' output using common quantitative and qualitative measures, we provide a novel avenue to study both the phylogenesis of vocal learning broadly and human language development.

Composition and Function of Private Speech in Humans

Most normally developing children begin to engage in private speech from 15 months to 3.5 years (Geurts, 2018; Kuczaj, 1983) which corresponds to a period of intense language development (Hoff, 2009; Schaerlaekens & Swollen, 1997). The composition and structure of private speech is similar to that of social speech (Mang, 1997) and may therefore provide opportunities for language practice through word play (Kuczaj, 1983) and metalanguage practice (Weir, 1970). After peaking around 2-3 years (Nelson, 1989), utterance frequency decreases between 4-5 years of age and becomes more abbreviated, harder to discern, and predicated on context (Berk, 1992). As private speech becomes more differentiated from social speech, it is gradually internalized and integrated with covert activity (Winsler et al., 2000). This decline in overt private speech during a period of continued language learning does not necessarily mean that children decrease practicing their emerging language skills. Rather, children may internalize practice as they acquire richer representation skills, such as internalization, which reduces the need for thoughts and ideas to be vocalized aloud (Vygotsky, 1962; Winsler, 2009; Winsler et al., 2000).

¹ In the human literature, different terms have been used to describe this phenomenon. These include crib speech (Mead & Winsler, 2019; Weir, 1970), self-speech (Kuczaj, 1983), self-talk (e.g., Winsler, 2009), inner speech (Vygotsky, 1962), and more broadly non-social talk (Geurts, 2018). Here, we intentionally use private speech as an umbrella term for vocalizing while alone to parallel the nonhuman literature (i.e., Pepperberg et al., 1991).

The presumed function of private speech changes as children develop. When still overt in younger children, private speech provides opportunities for sound- and word-play (Kuczaj, 1983; Mead & Winsler, 2019) and language practice (Weir, 1970). Freedom to talk without grammar or cohesion rules creates a space during which self-guided learning can take place without correction by others (Nelson, 1989). Indeed, the proportion of linguistic practice is more frequent in private speech than in social speech (Kuczaj, 1983). As private speech becomes less overt in older children, its function transforms from a tool for language play and practice to a metacognitive tool serving self-regulation and emotion-regulation purposes (Day & Smith, 2013; Nelson, 1989; Winsler et al., 2000). For example, as private speech becomes more task-relevant between 4-5 years (Winsler et al., 2003), older children often use motivational, self-affirming speech when engaging in difficult tasks (Atencio, 2004). In older children and adults, private speech supports a host of psychological functions including reasoning, problem-solving, planning, executive functioning, attention, and motivation (Geurts, 2018; Winsler, 2009; Winsler et al., 2000).

Composition and Function of Solo Vocalizations Among Avians

Many vocal-learning avian species vocalize while they are alone. Here, we use the term *solo vocalizations* broadly to describe this phenomenon, recognizing that wild avian species do not use speech as their communication system and only some captive species do. The composition of solo vocalizations among wild avian vocal learners reflects a pattern similar to humans in terms of content and ontogeny. Like humans, vocal learning birds must learn their vocal repertoire by interacting with conspecifics. As such, juvenile parrots, for example, spend a great deal of time socializing with each other then copying what they learn (Toft & Wright, 2015). The composition of wild vocal learning birds' solo vocalizing, then, is the active crystallization of species-specific vocalizations (e.g., Böhner, 1990; Doupe & Kuhl, 1999; Marler, 1970; Marler & Peters, 1982; Nottebohm, 1970; Nottebohm & Nottebohm, 1969). As they age and solidify their species-specific repertoire, content related to repertoire building should naturally decrease over time.

Parrots are vocal learning generalists and in captivity will reproduce environmental sounds as well as use speech sounds to communicate (e.g., Colbert-White et al., 2011). Private speech by speech-using parrots has been minimally studied (Colbert-White et al., 2011; Pepperberg et al., 1991). Though Baldwin (1914) was the first to document African Grey parrot private speech, Pepperberg and colleagues (1991) were the first to experimentally investigate the behavior. Their lab-reared parrot Alex was recorded before, during, and after label training. Their goal was to assess “consequence-free practice” as a common function of private speech among parrots and humans. The authors concluded Alex did, in fact, engage in practice of new labels, as evidenced by him first uttering semblances of new labels while alone up to seven weeks prior to uttering them with a social partner present. Furthermore, they noted that Alex's frequency of private speech changed as a function of condition (i.e., before, during, after label training experiments), indicating the day's events influenced private speech.

Similar patterns in captive parrot private speech were found more recently in a home-reared parrot. Colbert-White et al. (2011) recorded 12 hr of Cosmo, a then 6-year-old Grey parrot, in four different social contexts: alone, owner in another room but still willing to talk, owner in the same room and willing to talk, and owner in the room ignoring Cosmo in favor of talking with an unfamiliar house guest. They compared vocabulary richness, content, and possible functions across the four contexts and demonstrated that the composition of Cosmo's private speech was distinctly different from the three social contexts with her owner. For example, 90% of her top 10 vocalizations were nonword sounds while alone compared to 80% when socializing in the room with her owner, 80% when socializing in a different room from her owner, and 20% in the social exclusion context.

Compared to the three social contexts, Cosmo's private speech included significantly fewer requests for items to be given to her and fewer vocalizations that were associated with physical or vocal interaction with her owner (Colbert-White et al., 2011). This illustrated Cosmo treated being alone as a context that was distinctly different from social interactions with others. Transcriptions of Cosmo's private speech suggested there might be parallels to that of humans', however, Colbert-White et al. (2011) did not pursue an in-depth comparative investigation at that time.

Both Alex and Cosmo represent two encultured birds. Among their wild counterparts, the crucial function of solo vocalizations is for practice to refine the species-specific repertoire (Marler, 1970). Given that parrots are adept at reproducing and incorporating other species' vocalizations into their repertoire (Toft & Wright, 2015), a great deal of time would need to be spent solidifying their heterogeneous vocal code. Additionally, as Toft and Wright (2015) assert, the complex social lives of parrots necessitate practice in order to remain included in their social group. Especially because some individuals disperse and need to be accepted into new groups with different dialects, practice affords the opportunity to enhance social skills which aid in their survival and reproduction.

A second function of private speech Pepperberg et al. (1991) concluded with Alex was play. The authors noted the novelty Alex demonstrated with word usage and unique solo dialogues was evidence not just of practice, but of play. Burghardt (2011) provides one of many definitions for play. He describes five criteria: a behavior not necessary for immediate survival; one that is spontaneous, voluntary, rewarding; one that is not fully functional (e.g., play fighting); one that is performed repeatedly but not stereotyped; and one that is initiated when all physiological needs are met (Burghardt, 2011). According to this multi-pronged definition, word- and sound-play could very likely be present in parrot private speech similar to what is seen in humans (Hoff, 2009). Among some vocal learning bird species, elaboration of the vocal code (e.g., unique syllables, repertoire size) correlates with mate choice (Robinson & Creanza, 2019). As such, the ability to vocally improvise or innovate would likely need to be present for this and it is reasonable to predict that such improvisation could, outside of reproductive contexts, occur as a form of play.

Since the 1980s, the parrot speech literature has focused almost exclusively on parrots' vocal output while they are interacting with a social partner (e.g., Ain et al., 2009; Colbert-White et al., 2011, 2016; Giret et al., 2010; Pepperberg, 2007; Pepperberg & Wilcox, 2000; for review, see Pepperberg, 1999). Because of this, documented comparisons to human language are limited to communicative competence, syntax, and grammar broadly in communication with others. A cross-species private speech investigation, however, affords the opportunity to examine how a nonhuman speaker uses an artificial communication system for themselves, and not in relation to or at the request of others. By removing the social constraints, we can gain a unique perspective into how the same general system is being used spontaneously by speakers of two different species.

Though this study is largely exploratory, we predict that there will be commonalities in the speakers' private speech. Specifically, because both speakers are members of highly social vocal-learning species, we predict evidence of repetition of sounds, words, and/or phrases by both speakers indicative of practice to refine their repertoire. This repetition may also qualify as play according to Burghardt's (2011) definition. Finally, given both species' natural history, utterances related to social interactions are also predicted to be present given speech is both speakers' primary modes of interaction with their caregivers.

Method

Speakers

One human child and one home-reared African Grey parrot were the speakers in this study. Beginning in 1982, Nelson recorded the private speech of a child named Emily from the time when she was almost two years old until around her third birthday (see Nelson, 1989). Because private speech peaks during this age range for normally-developing children (Nelson, 1989), these recordings provide a rich window into the vocalization composition and function of Emily's private speech. Emily was the first-born child and was considered to be verbally precocious for her age. Indeed, Emily's verbal abilities were quite advanced when compared to her peers (Nelson, 1989). For this reason, Emily's productions can be described as narratives since they combined complex vocabulary and grammar in pragmatically appropriate ways. Both parents incorporated complex words and sentence structures into their Motherese-like grammar during conversations with Emily. During the time of taping, Emily was enrolled at a daycare center where she regularly interacted with caregivers and peers.

The private speech of Cosmo, an African Grey parrot, was recorded over the course of 11 months from 2007-2008 beginning when she was six-years old. BJ purchased Cosmo from a pet store in 2002 when she was six-months old. While Cosmo had extensive experience hearing other human speakers in and out of the home, BJ was her only consistent companion. Cosmo whistled in duets with BJ until she began using words at twelve months. BJ used a simplified grammar with limited vocabulary to label new objects for Cosmo and to correct Cosmo's misuse and mispronunciation of words. From social interactions with BJ, Cosmo acquired melodies, English speech, and some nonword sounds like *kiss* noises. Other vocalizations were acquired spontaneously from the environment (e.g., dog bark and garbage truck beeping).

Recordings and Transcriptions

Emily's parents tape-recorded 122 private speech events while Emily was alone in her crib during naptime or bedtime. Data collection was pre-arranged by Nelson to occur during times when Emily's parents believed she was most likely to engage in private speech. Importantly, because private speech is known to be quite sensitive to setting (Winsler et al., 2000), these naturalistic recordings were expected to be a more accurate assessment of behavior. Further details about the recordings and transcription process can be found in Nelson's (1989) account of the study.

BJ videotaped Cosmo alone in her primary enclosure (55.9 × 61.0 × 83.8 cm, with perch extending 40.6 cm from top) as one of four social contexts in Colbert-White et al.'s (2011) investigation. For three weeks prior to testing, Cosmo was habituated to a Sony DCR-TRV39 mini-DV video camera on a tripod 1.5 m from her enclosure. After the habituation phase, BJ recorded five sessions where she was instructed to leave the house immediately after starting the video camera. Similar to Emily's parents, BJ was asked to record when Cosmo seemed particularly talkative in the time leading up to BJ's departure. Two dogs also lived in the home and had full access to the house while BJ was gone.

Cosmo videos were transcribed using the code "ID" (i.e., indistinguishable) whenever vocalizations were not clear. Syllables and fragments were transcribed as they were heard (e.g., *tele* and *showe* as in *telephone* and *shower*, presumably). To decrease experimenter bias and to parallel Nelson's (1989) use of only audio-recordings, contextual information from the videos was not used to construct the transcriptions. Nonword sounds were transcribed with two- or three-letter codes (refer to Table 1 for examples; full list of codes appears in Colbert-White et al., 2011). An independent observer transcribed 13% of the overall dataset of four different contexts. "Matching" required both timestamps and vocalizations to be identical between the transcribers. The Cohen's kappa coefficients of reliability for seven randomly-selected reliability samples of private speech transcriptions ranged from $\kappa = .38-.79$. When the .38 outlier was removed, the median kappa coefficient rose from .67 to .72.

Table 1*Ten Most Frequently Used Vocalizations*

| COSMO | | EMILY | |
|--------------|-----------|--------------|-----------|
| Vocalization | Frequency | Vocalization | Frequency |
| NWM | 205 | and | 158 |
| DS | 150 | I | 122 |
| WBI | 128 | to | 105 |
| DW | 69 | the | 87 |
| PH | 66 | you | 63 |
| OOO | 35 | my | 57 |
| DUW | 31 | a | 56 |
| hello | 29 | we | 41 |
| RI | 28 | go | 40 |
| MWH | 22 | choo | 37 |

Note. NWM = other non-whistle sound; DS = dog bark, gruff, or howl; WBI = wild songbird vocalization; DW = dog whimper; PH = telephone dial beep; OOO = “ooh” (long-*o* sound); DUW = duet whistle; RI = telephone ring; MWH = other one-note whistle; choo = train sound

Corpora

Emily’s corpus (i.e., body of text, transcriptions) consisted of 30 randomly selected transcriptions taken from the Child Language Data Exchange System (CHILDES) online database. Data clean-up included deleting metadata and dialogue between Emily and her parents, along with deleting Nelson’s “best guesses” and interpolations for uncertain words. Typos were corrected and hyphens removed (e.g., *play-pen* became *playpen*) to be consistent with Cosmo transcriptions. All punctuation (e.g., brackets, question marks, and mark-up characters) were also removed. Emily’s first five lines of private speech after her parents left the room were arbitrarily omitted from the analysis to control for the effect of her parents leaving the room. The resulting Emily corpus consisted of 3,470 utterances.

Cosmo’s corpus contained three hours of usable footage from across the five alone sessions from Colbert-White et al. (2011). Similar to the Emily corpus, indistinguishable vocalizations were omitted, and word fragments were left in so that their frequencies and significance within the corpus could be assessed. To control for the effect of BJ leaving and returning, Colbert-White and colleagues (2011) arbitrarily removed the first and last two min of each transcription. The Cosmo corpus contained 2,630 utterances.

Data Analysis

The AntConc (Version 3.2.1w, Laurence Anthony, Waseda University, Tokyo, Japan) freeware program was used to create wordlists. Concordances (i.e., lists of vocalizations appearing *n* vocalizations to the left and right of a selected keyword in the corpus) and other visualizations of the data were also made in AntConc. The C5 CLAWS (Constituent Likelihood Automatic Word-tagging System, University Centre for Computer Corpus Research on Language, Lancaster University, Lancaster, UK) online part-of-speech tagger annotated parts of speech for all words in the corpora.

Results and Discussion

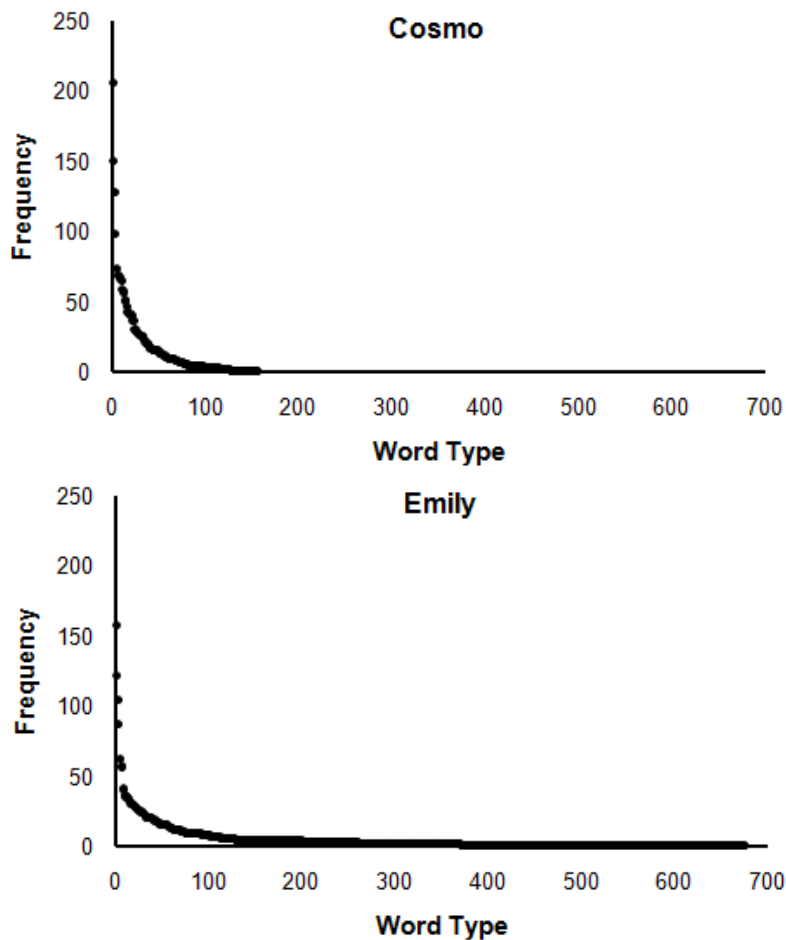
Composition of Private Speech

Language Curves

Frequency plots for both corpora followed the asymptotic trend described by Zipf's Law (Zipf, 1949) where a few words composed a large proportion of the frequency list and most words were only vocalized once (see Figure 1)². For the Emily corpus, these data provided evidence that even two-year-old children produce speech patterns that are similar to adults. Even more, these patterns were maintained during private speech, a time when normal speech patterns would not necessarily be predicted.

Figure 1

Asymptotic Curves Plotted from Cosmo and Emily Corpora



Note. "Word Type" indicates distinct vocalizations (i.e., word or nonword sounds).

² For the purposes of this paper, unless otherwise specified, *word* indicates any discrete vocalization, regardless of whether it was speech or a sound humans would not describe as speech (e.g., whistle).

Applying Zipf's Law to nonhuman animal communication systems has been met with some opposition. McCowan et al. (1999) incorporated Zipf's Law into analyses of bottlenose dolphin (*Tursiops truncatus*) whistle repertoires as a preliminary investigation of the feasibility of using the curve to describe nonhuman repertoires. The results of that study and a subsequent one applying Zipf's Law to squirrel monkey (*Saimiri sciureus*) vocalizations (McCowan et al., 2002) concluded that features of information theory, specifically Zipf's Law, could be applied to nonhuman animal communication systems to predict vocal repertoire structure. Despite a rebuttal from Suzuki et al. (2005) who claimed that Zipf's Law was appropriate neither for nonhuman animal communication systems nor for human language, this quantitative linguistic approach has been applied to numerous other nonhuman species (e.g., Clink et al., 2020; Kershenbaum et al., 2021).

Similar to findings by Kershenbaum et al. (2021) and McCowan et al. (1999, 2002), Cosmo's vocal patterns fit on an asymptotic curve. If Cosmo's utterances were vocalized randomly with little or no predictability in their use, then the distribution would appear flat (McCowan et al., 2005). Similar to human speech, however, the individual words in Cosmo's repertoire have unequal probabilities of being uttered, indicating a complex use of the vocal units comprising the repertoire.

This pattern may have an alternative, simpler explanation worth noting. Colbert-White et al. (2011) identified Cosmo's vocabulary as being comprised of individual utterances as well as holophrases—that is, one or more vocalizations strung together with a specific meaning (e.g., "Cosmo wanna go for a walk"). Unlike the natural nonhuman communication systems studied by McCowan and colleagues (1999, 2002) and Kershenbaum and colleagues (2021), Cosmo's multi-word holophrases represent an artificial code learned from BJ. If BJ's speech with Cosmo followed an asymptotic trend (as we would presume), this may explain why Cosmo's speech also followed the same pattern. Unfortunately, a method does not yet exist to determine the meaning behind the observed asymptotic trend in Cosmo's vocalizations. Still, the similarity of a parrot's artificial code to natural human and nonhuman communication systems does indicate, if nothing else, that parrots can adopt an artificial code and, from a computational perspective, use it as if it is natural.

Breadth of Vocabulary

Emily's corpus contained 3,470 tokens (i.e., vocalizations) with 670 types (i.e., different words). Cosmo's corpus consisted of 2,630 tokens with 155 word types (see Figure 1). Though Emily's corpus is only one-third larger than Cosmo's in terms of tokens, the number of types is four times larger, illustrating a disproportionately larger vocabulary. Emily had a much greater percentage of words only used once (9% versus 1% for Emily and Cosmo, respectively), and her lexicon included more obscure words such as *destroyed*, *flaming*, and *zucchini*. By contrast, 20% of Cosmo's single-occurrence utterances were fragments of pre-existing words in her repertoire such as *gon* and *kay*, and an additional 10% were gibberish words such as *baylog* and *feak*. Compared to Cosmo's 30% of fragments and gibberish, 13% of Emily's single-occurrence words were fragments or gibberish.

The issue of life enrichment, that is, the prevalence of opportunities for an individual to hear and acquire new words, is important to note as it is considered to play a large role in how, when, and to what extent language is acquired (Kuczaj, 1983). Cosmo is a pet, and Pepperberg's Alex lived in a lab. Both had experiences outside of their "homes," as well as interactions with different humans, but far fewer in comparison to a normal two-year-old child growing up in the United States. For example, Emily attended daycare and therefore had regular access to peers and adults of different ages. BJ also used a highly simplified grammar with Cosmo, which may have set a low ceiling for Cosmo's vocabulary expansion.

Our prediction related to social content being present in both speakers' private speech was supported. While only one of Cosmo's ten most frequently used vocalizations was speech (i.e., *hello*), it is a fundamental social utterance for her (see Table 1). Further, two nonword vocalizations, DS (i.e., imitation of BJ's dogs barking) and DUW (i.e., whistling *Bridge on the River Kwai* from the 1957 film of the same name) have strong social connotations for Cosmo. A review of the video footage indicated that the dogs did sometimes come into the room when Cosmo barked. Similarly, DUW is a turn-taken whistling duet that serves a bonding function for Cosmo and BJ (Colbert-White et al., 2011). Interestingly, though speech is BJ's dominant mode of communicating with Cosmo, speech is not represented in similar proportions in Cosmo's private speech. This suggests Cosmo draws some distinction between speech and nonword sounds. We revisit this pattern in our analysis of private speech functions.

Like Cosmo's, Emily's private speech contained highly social content. Specifically, two of her most frequent vocalizations were *you* and *we*, both of which indicate a social partner. As both speakers are members of social species, it is no surprise that the content of their private speech would contain common elements of social interactions with others, regardless of the reason.

Use of Conjunctions

As shown in Table 1, Emily used the word *and* more frequently than any other word during her private speech sessions. A concordance of *and*, *but*, and *or* revealed she used the words to link many ideas (See Table 2). Other instances included using conjunctions to link individuals' names, as well as one outlier, *and fetch*, which was repeated nine times in a row with no context surrounding it. Mostly, conjunctions continued Emily's vocalization stream as in *we going outside / and look at the flower / and not now*. This use of conjunctions created a story-like net of connected (and sometimes nonconnected) ideas and retellings which snowballed in complexity as more conjunctions were added.

Table 2

Emily's Frequency of Use of Conjunctions During Private Speech

| Type | CONJUNCTION | | |
|---------------|-------------|-----|----|
| | and | but | or |
| Ideas | 126 | 28 | 4 |
| Names/Objects | 24 | -- | 8 |
| Other | 8 | 2 | -- |
| Total | 158 | 30 | 12 |

Note. "Ideas" = e.g., "we going outside / and look at the flower / and not now"; "Names" = e.g., "Mommy and Daddy" or "a truck / or a air plane / or a helicoptertor."

The Cosmo corpus did not contain *and*, *but*, or *or*. However, Colbert-White et al.'s (2011) larger dataset from which the current study's corpus was sampled showed that Cosmo did vocalize the word *and* in units such as *Cosmo and Betty Jean wanna whistle*, but the joining of discrete repertoire units by conjunctions (e.g., "Betty Jean wanna whistle *and* Cosmo wanna peanut") was not observed. The presence of *and* in Cosmo's vocalizations but lack of use of it during private speech further supported Colbert-White et al.'s (2011) finding that many of Cosmo's repertoire units contained words which were not learned individually, but rather were learned as parts of holophrases.

In comparison, Emily recombined repertoire units and generated novel ideas using conjunctions to connect clauses. The child literature does discuss very early language-learners' use of fixed utterances combined with variable endings, called substitutions (Kuczaj, 1983). An example of this from Cosmo's speech is the word *that's*, which appears to be fixed, as it could be followed by a wide range of substitutions, including *water*, *doggie bark*, or *wanna water* (see Kaufman et al., 2013, for evidence of higher-level semantic structures in Cosmo's repertoire). Emily appears to have progressed beyond this reliance upon substitution, and her private speech contains clear evidence of generativity. Recognizing the challenges associated with making cross-species comparisons at face value, this would place Emily's linguistic competency beyond Cosmo's.

Use of Verb Tense

Both speakers' verb use frequency was similar (see Table 3). Both speakers also imitated their caregivers' last words to them (e.g., *She said good nap* and *Be back soon*). Emily's repetition of her parents was reported in past tense while Cosmo retained the verb tense originally used by BJ (e.g., *Okay let's go Betty Jean have to go in a car* and *We're gonna go for a walk*). In these and most other situations, Cosmo's use of verbs, even when referring back to her caregiver's words from the past, never occurred in past tense. Instead, Cosmo repeated the words how they were spoken to her, either in present or future tense. On the other hand, Emily used past, present, and future tenses appropriately and flexibly in her vocalizations.

Table 3

Verb Tense Frequencies for Cosmo and Emily

| Verb Tense | Cosmo | Emily |
|------------|-------|-------|
| Past | 4 | 128 |
| Present | 318 | 243 |
| Future | 51 | 27 |
| Total | 373 | 365 |

Reviewing the Emily corpus, past tense verbs were used to retell stories of events that happened in the recent past. The four incidences of past tense for Cosmo were imitations of BJ's answering machine (*You have reached [Betty Jean's phone number]*) and BJ being bitten by Cosmo ([ouch pain sound] *that hurt*). Cosmo's lack of use of past tense may reflect an inability to vocally report on past events but could also be the result of BJ's simplified grammar failing to provide a language environment that would have enabled Cosmo to learn to appropriately report on the past.

If there is a true inability to report on the past, it would align with a natural history perspective on communication in nonhuman animals. Specifically, of the many proposed features that distinguish nonhuman communication systems from human language, *displacement* (i.e., the ability to communicate information out of temporal context) is the most relevant here. According to Shettleworth (2009), most nonhuman animals do not need to communicate in the present about predators or food sources in the past. A memory and learned association formed through these interactions are sufficient for survival. Thus, the ability to first reflect upon the past and then communicate about it later may not have evolved in African Grey parrots because of a lack of need. Nonetheless, there is at least some evidence that humans' private speech can serve a reflective function (Winsler, 2009; Winsler et al., 2000). It is possible, therefore, that Cosmo may use the simplified, largely present tense grammar she learned as her method of reflecting on the past in a functionally similar way. To explore this experimentally, Cosmo could be exposed to a novel situation or object while she is alone, then observe the content of her private speech and social speech with BJ shortly thereafter.

Content vs. Function Words

As shown in Table 1, content words (i.e., nouns, adjectives, and verbs) were predominant features of the Cosmo corpus while the Emily corpus was comprised largely of function words (i.e., prepositions, articles, pronouns, conjunctions). Early on, content words allow the language-learning child to efficiently transfer information. It is only as the child ages that function words allow for the transfer about more complex ideas through the use of prepositional phrases, nested clauses, and stringing of phrases with conjunctions. Assuming Cosmo was exposed to function words during social interactions with others, and while attending to social interactions between BJ and others, her lack of incorporation of function words contributed greatly to the rigidity of her repertoire use, and further supported Colbert-White et al.'s (2011) finding that her private speech was largely comprised of holophrases.

Function of Private Speech

Sound- and Word-Play

As Crain et al. (2013) discuss, the field of animal cognition is fraught with constructs that either have no universally agreed upon definition or are presented by authors without operational definitions to anchor them. This muddies the waters of communication among researchers. To increase clarity, we made an ad hoc decision to use Burghardt's (2011) definition of play in our investigation. In support of our prediction, both Emily and Cosmo appear to engage in what Burghardt (2011) classifies as sound- and word-play while alone. Sound-play was defined as any repetition or recombination of phonemes or nonword sounds. Since use of nonword and speech sound varied differentially across social context (Colbert-White et al., 2011), this class of vocalizations was considered as distinct for Cosmo as speech sounds and nonword sounds were for Emily.

Neither repetition nor recombination of English phonemes were present in the Cosmo corpus. However, 9 of the 10 most frequently used vocalizations in the Cosmo corpus were nonword sounds (e.g., wild bird warbles, dog barks, see Table 1), indicating a strong bias toward vocalizing and repeating nonword sounds over speech sounds while alone. Furthermore, of the 9 nonword sounds on the list, 7 were sounds with presumably no communicative function (e.g., telephone beep). Cosmo may have vocalized nonword sounds more frequently when alone because (a) they are somehow easier for her to vocalize; (b) they are more difficult for her to vocalize and therefore must be practiced; (c) they do not require a social partner's participation; (d) they have some intrinsic value (e.g., play or enjoyment); and/or (e) being alone privileges a different kind of engagement with vocalizations than when her predominantly speech-using owner is at home with her.

There was evidence of complex phonemic sound-play in the Emily corpus (see a list of examples provided in Table 4). Unlike in the Cosmo corpus, however, only 1 nonword sound appeared in Emily's 10 most frequently used vocalizations—a train *choo* sound. This confirmed speech was Emily's predominant medium of vocalizing, even when alone.

Table 4

Examples of Emily Corpus Phoneme Sound-Play

babababa (10x in a row)

pau (16x in a row)

uapaneua

uatauamauatauasha

fafataratabibibibi

dabudadaybudda (variations repeated 3x in a row)

baingbadabeinbadaba

binabeemabombadebinadepontain

debimadebeemadebomabinnadebinade

Both speakers frequently engaged in word-play, defined as repetition of words or word structures. Examples from the Emily corpus included *teen / teen / teenah Tina / Tina / Tina*, and *good nap / nap / nap / nap / she said good nap / nap / nap*. Though for Cosmo most repeated vocalizations were nonword sounds, instances of repetitions of words did exist, including *step up here / step up / step up / up up up up up up*, *time for shower / time for Betty Jean / time* and *let's go back Cosmo be back okay back*.

Sound- and word-play during private speech demonstrate the linguistic freedom associated with the absence of a social partner. Sound- and word-play are intrinsically rewarding to children, and imply some level of enjoyment (Kuczaj, 1998; Kuczaj & Makecha, 2008). If an African Grey can be taught to use speech to communicate, and its private speech shows evidence of and bias toward sound- and word-play, the parrot may consider alone time to be a “break” from social vocalizations and an opportunity to enjoy vocal play. Further, children and dolphins engage in forms of play that challenge their abilities (Kuczaj et al., 2006; Kuczaj & Makecha, 2008; Kuczaj & Walker, 2012), and Cosmo may have enjoyed the opportunities provided by her private speech to challenge herself vocally. Unfortunately, of all of Burghardt’s (2011) five criteria for play, this rewarding element is the one that is most difficult to assess and confirm. The other criteria, that play is spontaneous, voluntary, not fully functional, repeated behavior, and initiated when all physiological needs are met certainly do apply here for both speakers.

Vocalization Practice

As Weir (1970) described, private speech offers young speakers the opportunity to practice articulation of words and new labels, as well as the choice not to correct errors. Our prediction of repetition indicative of practice was also supported. Both Cosmo and Emily used their alone time to practice new speech labels. Cosmo practiced articulation of *television* in *that's televi / televi* and *that's televi / wanna go to work / ooh / televi / televi*. According to a personal communication with BJ (2008), BJ had begun incorporating the word into conversations with Cosmo during the months of data collection. For Emily, *helicopter* appeared to be a similar practice word, *or a hellcoptertor / or a hellicopter / a hellicopter / hellicopter / hellicop / hellicop / helicopter / helicopter*.

Without knowing the context, commenting on the speakers' practice of labeling is difficult. However, both speakers appeared to engage in this behavior. Emily flexibly labeled objects, as in *one blanket / two blankets / bear blankets*, and *this is my arm my head my hair*, while Cosmo was more fixed in her labeling (e.g., *that's squirrel*, [dog bark imitation] / *that's bark*). Emily's developing generativity was apparent in her incorporation of labels into her narratives, while Cosmo's labeling always followed a pattern using the fixed word *that's* with substitutions (a more basic method).

Along with word and label practice, children's private speech often includes practice in the form of spontaneous repair of utterances through modification and error-correction (Kuczaj, 1983). One instance of possible error correction was identified in the Cosmo corpus, *Betty has feathers [whistle] hair*. In conversations with Cosmo, BJ often made the distinction that Betty Jean has hair, Cosmo has feathers, and "doggies" have fur (Colbert-White et al., 2011). Thus, it is plausible for Cosmo to make such an error and repair it. Possible error-correction and/or modification in the Emily corpus included *I I eat / I need to eat* and *...on the inside the door / inside the barn door*.

While Cosmo and Emily both appear to use private speech as a time of freedom to correct errors and improve vocal production, there were also frequent incomplete phrases and words including, *Emmy would take the paper off of the* for Emily and *Betty Jean has gla* and *Betty Jean have to* for Cosmo. This lack of cohesion occurred even within clusters of similar phrases as in *my cough is like / this is / cough* in the Emily corpus. Based on these data, both speakers do appear to distinguish being alone as a time for verbal experimentation and freedom.

Practice, modification, and error-correction all require that the speaker monitor what is being said and how it is being articulated. Further, as with Cosmo frequently repeating DS and DUW, it is possible her private speech is an opportunity to refine two vocalizations that allow her to connect with social partners. In the case of both speakers, there is no external reward associated with monitoring or correcting their vocalizations. This could be supplementary evidence for both speakers that as with sound- and word-play, practice could also be intrinsically reinforcing as it can strengthen social skills associated with communication.

Self-Soothing

A review of both caregivers' comments at the beginning of taped sessions showed that Cosmo and Emily tended to repeat or summarize what happened and what their caregivers said just prior to departing. This usually occurred soon after the speakers were left alone and shortly before they both branched off into more tangential musings. Examples included Emily's reframing into past tense what she was told in *Good nap / nap / nap / she said good nap* and the verbatim *Okay we'll be back soon* for Cosmo. Separation and isolation can be stressful for members of social species; revisiting and recreating social interactions may have served a self-soothing function for Emily and Cosmo when they were left alone. Indeed, authors note private speech as one avenue for self-regulation and emotion-regulation in young children (Day & Smith, 2013; Nelson, 1989; Winsler et al., 2000). Perhaps Cosmo, too, was afforded some soothing function with her repetitions.

An alternative explanation is that for parrots and young children, more recent stimuli are more salient and therefore more likely to be repeated, particularly if the stimuli involve the speech of their caregivers to whom they are strongly attached. Regardless of the purpose, both species seemed to find something fundamentally memorable about their caregivers' "last words" to them before departing, so much so that these last words were incorporated into private speech content.

Social Skills Development

Vygotsky (1962) stressed the importance of socialization in language acquisition. Two features of the corpora, asking questions and engaging others while alone, appeared to support the social function of early language in children and language-like behavior in encultured parrots. Emily and Cosmo often posed questions that required a second party to answer. Concordance data are summarized in Table 5. Cosmo's interrogatories began with *where* and *what*, asking such questions as *Where are you?* and *What's [object].* Emily's questions were arguably more complex (e.g., *Can you show me how little bunny? How do you know?*). Further, Emily's questions often appeared to be imitations of one of her parents, as in *Why were you running around in Stephen's room?*

Table 5

Use of Questions by Cosmo and Emily

| SPEAKER | QUESTIONS | | | | |
|---------|----------------|---------------|-------------------------------------|--------------|---|
| | What | Where | Can | How | Why |
| Cosmo | 's bach? | are you? | | | |
| | 's that? | Cosmo? | | | |
| | 's bye? | wan[na] go? | | | |
| | 's baylog? | | | | |
| Emily | are you doing? | is Emmy? | I help you? | do you know? | (9x alone) |
| | is on? | is I come in? | you show me how little bunny? | | do you do that? did you do that? were you running around in Stephen's room? |
| | | | | | |

At first read, Cosmo's vocalization *Where Cosmo?* could be interpreted as an error characteristic of an individual that does not have a sense of self, or sense of ownership of the label that we call a name. However, Emily, too, asked, *Where is Emmy?* The term "mimic" is sometimes used to describe parrots' speech behavior. However, young children also mimic as they learn aspects of their native language, and such behavior is considered a component of the normal imitation phase associated with learning language. Though self-recognition by African Grey parrots has yet to be confirmed, the extent to which such speech vocalizations of nonhumans like Cosmo extend beyond mimicry is deserving of further study.

Generally speaking, asking questions may be indicative of imagined scripted encounters (that have happened in the past or are anticipated in the future). Young children engage in scripted role-play during social interactions like requesting (Ervin-Tripp et al., 1990). Asking questions may serve the function of building communication skills for later social interaction. Further, questions like *What's [object]?* may be scripts of previous interactions with caregivers. This importance of a social component is also revealed in the way both Emily and Cosmo appear to engage others while alone. Emily involved her stuffed animals by asking them questions and creating stories about them (e.g., "*no I don't know how to whisper / I didn't know how / can you show me how little bunny and you know something choo choo train / it should be dark outside*"). While Cosmo did not have toys to engage socially while BJ was out of the house, she may have solicited social interaction from BJ's two dogs given the dogs did sometimes bark back when Cosmo barked, and the footage revealed one dog named Mary came into the room when Cosmo imitated BJ's voice saying *Mary come on / [whistle] / come Mary / [whistle] / come on*.

General Discussion

This comparative analysis is the first of its kind to use corpus linguistics techniques to focus not on comparisons grounded in grammar and syntax but instead on composition and function. Analysis revealed several similarities and differences in the private speech of a two-year-old child and a six-year-old African Grey parrot. Both speakers' private speech followed Zipf's Law and contained evidence of sound/word play, word practice, social skills practice, and possible self-soothing by imitating their caregivers' reassuring phrases. When compared to Emily, Cosmo (1) had a smaller vocabulary; (2) uttered more content words than function words; and (3) showed almost no evidence of conjunctions or past tense in her utterances. We approach the framing of our interpretation of these patterns through the lens of species' natural history.

Many scholars have concluded that various avian species (including African Greys) practice and play with features of their vocalizations (Doupe & Kuhl, 1999; Kuczaj, 1983; Marler, 1970; Nottebohm, 1970; Pepperberg et al., 1991). Relating this to a pet parrot being taught speech, we showed evidence of one of many parallels between parrot speech and child language. Both African Greys and humans are highly social species, so practicing while alone may reflect the common motivation of children and parrots to refine the vocal code required to be a member of the social group to which they belong. For Cosmo, this vocal code is artificial, while for Emily it was species-specific. Additionally, sound- and word-play may be intrinsically rewarding in and of themselves, and such play incidentally facilitates an increase in vocal sophistication. Distinguishing the motivation(s) of play is difficult in general (Burghardt, 2005), and especially so when considering language play in humans (Kuczaj, 1998).

A comparison of the speech being directed to Cosmo and Emily reveals a few possible explanations for the differences that were observed in composition of their private speech. While transcriptions of Emily's parents revealed that they encouraged vocabulary expansion, BJ spoke to Cosmo using a highly simplified grammar and vocabulary. For example, during one of Colbert-White et al.'s (2011) taped sessions of BJ and Cosmo in the room together, BJ responded to Cosmo's "What's that?" with "That's paper Cosmo" rather than a more elaborate response such as "This is wrapping paper I'm using to wrap presents for Christmas." Differences in our two speakers' vocabulary breadth, use of function words, and varied verb tense may reflect differences in their input rather than abilities.

In humans, there is a tremendous amount of variation in how children are exposed to language. In some cultural contexts, children are spoken to directly (such as in Emily's case), while in other cultural contexts, adults may not speak directly to children (Pye et al., 2017). Even when not spoken to directly, children acquire language from overhearing conversations of others. While language development may be protracted in these situations, these children also acquire human language to adult competency (Pye et al., 2017). BJ frequently had company at her house and took Cosmo to work with her (BJ personal communication, 2009). This would have provided Cosmo with numerous opportunities to indirectly build her speech repertoire. Further, we know Cosmo is capable of such indirect learning due to her repertoire of nonword sounds from the environment. Still, Emily's regular attendance at daycare alone, for example, points to her vocal input being far richer and more frequent than Cosmo's, which could be reflected in Cosmo's limited speech output.

Moreover, young children readily repeat new words and can incorporate words into their vocabularies after only minimal exposure using a process called fast mapping (e.g., Carey, 1978; Woodward et al., 1994). For example, in a classic study, Carey (1978) demonstrated that after only a single exposure to a novel word, three-year-old children already developed hypotheses about what that word could mean. However, according to BJ (personal communication, 2012), Cosmo only acquired words that BJ repeatedly directed to her over a course of days or weeks. Similar observations have been documented in lab-reared individuals formally learning labels (e.g., four days, Pepperberg & Wilcox, 2000; seven weeks, Pepperberg et al., 1991). Differences in the complexity of input and the ability to incorporate new vocalizations heard only once offer two considerations when evaluating the composition distinctions we observed between Emily and Cosmo.

Comparing the two speakers' private speech at face value makes Cosmo appear to lack some requisite cognitive ability that would allow her to match Emily's vocabulary size and usage. However, such an interpretation would be inappropriate, and highlights one challenge of cross-species case studies such as ours. Emily's verbal abilities are quite advanced compared to her peers. For example, while Emily was found to produce 670 tokens in the current corpus, two-year-old children typically produce substantially fewer tokens (e.g., 130.10 tokens ($SD = 139.40$); Tomasello et al., 1986). By this metric, Cosmo's productions (155 tokens) are more similar to those of an average two-year-old child, while both are substantially less than the tokens produced in Emily's narratives.

While we report similarities and differences here, we do so without making assumptions about superior or inferior cognitive abilities. This is because we cannot discount the individual differences within a species and natural history differences between species which gave rise to our speakers' output here. Further, as some scholars note (e.g., Abramson, 2013), the terms *cognitive* and *cognition* make cross-species comparisons difficult due to their unagreed upon definitions. Instead, we assert that natural history offers a more informed framing for the composition differences we observed.

In the wild, parrots tend to have no more than a few dozen calls, that is, vocalizations with specific meanings, and their repertoires can also incorporate other species' vocalizations (Toft & Wright, 2015). Interestingly, we observed a mix of speech and nonword sounds in Cosmo's repertoire as well. As a result, it is unrealistic to hold expectations for equal vocabulary breadth when a captive parrot adopts speech as their communication system, has never had exposure to a species-specific tutor, and they are exposed to a large variety of auditory stimuli in their environment. Approaching the vocabulary differences from a place of curiosity in terms of which sounds captive parrots choose to incorporate into their system, why, and how offers far more interesting questions for future research.

In summary, we have detailed composition and function of private speech in both a language-learning child and a home-reared African Grey parrot. Both speakers' vocalizations appeared to be intrinsically reinforcing to members of both species, although their motivations are unclear. Perhaps the true motivation was simply to have fun with sounds, and this activity resulted in the practice and challenges that characterize private speech in humans. Our findings demonstrate that two speech-users—one for whom speech is the species-specific communication system and the other an artificial system—share starkly similar private speech functions. Recording solo vocalizations in other non-speech using species for the purpose of understanding solo vocalizing's evolutionary significance may reveal additional commonalities. Here, we have created more questions to consider with this systematic comparative analysis. The observed cross-species patterns suggest private speech is an understudied avenue through which the ontogeny and evolution of language can be further explored.

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