Journal of Comparative Psychology

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Online First Publication, March 7, 2011. doi: 10.1037/a0022097

CITATION

Colbert-White, E. N., Covington, M. A., & Fragaszy, D. M. (2011, March 7). Social Context Influences the Vocalizations of a Home-Raised African Grey Parrot (Psittacus erithacus erithacus). *Journal of Comparative Psychology*. Advance online publication. doi: 10.1037/a0022097

Journal of Comparative Psychology

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0735-7036/11/$12.00 DOI: 10.1037/a0022097

Social Context Influences the Vocalizations of a Home-Raised African Grey Parrot (*Psittacus erithacus erithacus*)

Erin N. Colbert-White, Michael A. Covington, and Dorothy M. Fragaszy
University of Georgia

Home-raised African Grey parrots (*Psittacus erithacus erithacus*) exhibit strong social bonding with their human companions. We examined how 1 parrot's vocal production (speech and nonword sounds) changed with social context with respect to descriptive measures of the vocalizations and their thematic content. We videotaped the parrot in 4 social conditions: subject home alone, subject and owner in the same room, owner in a separate room within hearing range, and owner and experimenter conversing in the same room as the parrot but ignoring her. Linguistic analysis revealed the parrot's repertoire consisted of 278 "units" ranging in length from 1 to 8 words or sounds. Rate of vocalization and vocabulary richness (i.e., the number of different units used) differed significantly, and many vocalizations were context-specific. For example, when her owner was in the room and willing to reciprocate communication, the parrot was more likely to use units that, in English, would be considered solicitations for vocal interaction (e.g., "Cosmo wanna talk"). When she and her owner were in separate rooms, the subject was significantly more likely to use units that referenced her spatial location and that of her owner (e.g., "Where are you"), suggesting she uses specific units as an adaptation of the wild parrot contact call. These results challenge the notion that parrots only imitate speech and raise interesting questions regarding the role of social interaction in learning and communicative competence in an avian species.

Keywords: African Grey parrot, speech, vocalization, social context, contact call

This research investigated the vocal production (i.e., speech and nonword sounds) of a pet Congo African Grey parrot (*Psittacus erithacus erithacus*). For our purposes, *speech* is defined as the vocalized pattern of sounds that are recognized as words. This is distinctly different from *language*, the system that uses speech to represent and communicate complex concepts (Fitch, 2000). Evidence of nonhuman animals (hereafter referred to as *animals*) replicating speech is limited to mammals and birds. In mammals, there is one documented harbor seal (*Phoca vitulina*; Ralls, Fiorelli, & Gish, 1985), one Indian elephant (*Elephas maximus indicus*; as cited by Tyack, 2008), and a handful of chimpanzees (*Pan troglodyte*; e.g., Hayes & Hayes, 1951) that have been taught to vocalize up to a few words. Conversely, numerous avian species are highly skilled at mimicking speech. Members of the starling (e.g., West, Stroud, & King, 1983), corvid (e.g., Noack, 1902), and parrot (e.g., Pepperberg, 1999) families are the best-known examples. We show that features of one African Grey parrot's spontaneous speech and nonword sounds vary with social context, indicating a level of understanding that goes beyond vocal imitation and approaches functional use.

Various aspects of psittaciforms' natural history make them exceptionally interesting candidates with which to study vocal behavior in variable social settings. Little is known regarding African Grey parrots' natural history, but social behavior across numerous parrot species is thought to be similar. Psittaciforms are generally reproductively monogamous and highly affiliative with flockmates (see Seibert, 2006, for review). In several species, pair-bonded individuals prefer close physical contact with their mates and some engage in antiphonal duetting (Nottebohm, 1972; Serpell, 1981). Many authors have noted that a majority of wild parrot repertoires is learned through social experience with parents or other flockmates (e.g., Nottebohm, 1972), implicating social interaction as an important component of vocal learning. When visual barriers separate individuals, many parrot species produce discrete sounds called "contact calls" (e.g., yellow-naped Amazon, *Amazona auropalliata*; Wright, 1996). The use of specific vocalizations to maintain social contact has also been documented in other bird species (e.g., tropical boubou, *Laniarius aethiopicus*, Thorpe & North, 1966; African forest weaver, *Symplectes bicolor*, Wickler & Seibt, 1980), as well as some highly social mammalian species such as elephants, *Loxodonta africana* (e.g., McComb, Reby, Baker, Moss, & Sayialel, 2003); dolphins, *Tursiops trunca-*

Erin N. Colbert-White and Dorothy M. Fragaszy, Department of Psychology, University of Georgia; Michael A. Covington, Institute for Artificial Intelligence, University of Georgia.

This research was submitted by Erin N. Colbert-White to the University of Georgia in partial fulfillment of the requirements for a Master's of Science degree in psychology. The work was presented at the 16th Annual International Conference on Comparative Cognition and the 32nd Annual University of Georgia Psi Chi Convention of the Behavioral Sciences, both in March 2009. We thank Stephen M. Shellman of Strategic Analysis Enterprises, Inc., who made the SAE Phrase Frequency Tool software available for our use; Cody Boisclair, Allison Kaufman, David Stedman, Elizabeth Yates, and Allison Eury for aid in data preparation and analysis; an anonymous reviewer for helpful suggestions in the Discussion; and Betty Jean Craige and Cosmo for their participation.

Correspondence concerning this article should be addressed to Erin N. Colbert-White, Department of Psychology, University of Georgia, Athens, GA 30602. E-mail: colbere@uga.edu

tus (e.g., Watwood, Owen, Tyack, & Wells, 2005); and some nonhuman primates (e.g., Cheney & Seyfarth, 1996).

With only a few exceptions, such as the investigation of self-speech by Pepperberg, Brese, and Harris (1991), studies of captive parrots' vocalizations have focused on topics related to referential learning and numerical competence using speech (e.g., Pepperberg, 1987, 1988, 2006; see Pepperberg, 1999, for review; Pepperberg, Gardiner, & Luttrell, 1999). These studies typically used question-and-answer paradigms. We know that social interaction can play a significant role in parrots' mastering concepts (e.g., sameness and difference of color, shape, and material properties) and cognitive tasks such as referential label learning (Pepperberg, 1994; Pepperberg et al., 1999). However, to our knowledge, the current study is the first to investigate the effects of social context on parrots' spontaneous vocalizations.

Any parrot owner can attest to the strong social bonding that occurs between human caregivers and their home-raised African Greys. Home-raised parrots often treat their human caregivers like a conspecific pair mate. Because speech can replace or be used in conjunction with species-typical vocalizations in captive parrots, we hypothesized that one function of the spontaneous speech (and other discrete nonword vocalizations) that home-raised parrots produce is to maintain social contact with their owners. Thus, we expected that a linguistic analysis would provide evidence that some vocalizations in the parrots' repertoire serve the function of a wild parrot contact call.

To test this, we videotaped one parrot, Cosmo, in four distinct social contexts. If Cosmo uses vocalizations spontaneously to promote interaction or to maintain contact with her caregiver, she should vocalize differently when her caregiver's physical presence and willingness to reciprocate interaction are manipulated. Specifically, across contexts, we expected differences in measures of Cosmo's vocalization rate and vocabulary richness (i.e., the percentage of her full repertoire that she uses). We also expected that differences would be apparent in the content of the vocalizations themselves. That is, during periods of visual separation, Cosmo's vocal production should contain more vocalizations that, in English, refer to spatial location, request the owner to come in close proximity to the bird, or solicit vocalizations from the owner. Any of these findings would indicate that some pet parrot vocalizations can serve the function of a contact call to their human caregivers.

Method

Subject

Cosmo, a female Congo African Grey parrot that was 6 years old at the time of the study, served as the subject of the investigation. Cosmo's female owner (B.J.) purchased her from a pet store in 2002 when she was 5 months old. Although Cosmo had some experience hearing other human speakers, B.J. was her consistent companion. B.J. established a simplified grammar with limited vocabulary by labeling new objects for Cosmo and correcting Cosmo's misuse and mispronunciation of words. Social interaction with B.J. was the sole means by which Cosmo acquired melodies, English speech, and some nonword sounds like kiss noises. Two dogs also resided with B.J. and Cosmo at the time of the investigation.

Apparatus

All experimentation was conducted at B.J.'s home with Cosmo in her primary cage ($55.9 \times 61.0 \times 83.8$ cm, with perch extending 40.6 cm from top), which was located in a sun room facing B.J.'s reading chair 2 m away. Three weeks prior to initiation of data collection, we positioned a Sony DCR-TRV39 mini-DV video camera on a tripod 1.5 m from Cosmo's cage to allow her to habituate to the equipment. Cosmo's cage was the only object in the camera frame. The camera's built-in microphone (32 kHz, 16-bit audio) recorded all audio. B.J. taped 60-min sessions at her convenience from October 20, 2007, until August 12, 2008.

Experimental Procedure

Data were collected for four social contexts: In the alone (AL) context, B.J. began recording and left her house for the duration of the session. For the in (IN) context, B.J. sat in her reading chair and interacted with Cosmo as normal. In the out (OUT) context, B.J. remained in an adjacent room, but interacted with Cosmo as normal. In the company (CO) context, the experimenter and B.J. sat in the same room with Cosmo and simulated dialogue by taking turns reading from online blog entries. Care was taken to imitate natural speech by using inflection, laughter, and other conversation features. Throughout CO sessions, the experimenter and B.J. ignored Cosmo by refraining from interacting with her, talking about her, or making eye contact with or body gestures toward her. According to B.J. (personal communication, June 2, 2008), this was a highly unusual social context for Cosmo.

Transcriptions and Coding

Transcriptions were typed with a timestamp, identification of speaker, and vocal content. All background sounds were omitted. As with Nelson's (1989) transcriptions of her child subject, we used subjective pause lengths between utterances to segment the vocalizations by line. Often, two or more nonword vocalizations appeared on the same line if they occurred in close temporal proximity to each other. We phonetically transcribed syllables and fragments (e.g., *tele* and *showe* for *telephone* and *shower*, respectively). Cosmo's inaudible or questionable English vocalizations (e.g., *beak* and *feet* were often difficult to distinguish) were identified like Nelson's transcriptions, but with the code "ID" instead of question marks. Depending on the length of an utterance, multiple IDs served as codes for strings of indistinguishable vocalizations. Syllabic combinations were transcribed together as they were heard (e.g., "goodbye" followed by "I love you" was transcribed as "good byelove you" if the "I" was not articulated distinctly). With the exception of possible homophones, contextual information was not used to construct transcriptions to avoid bias.

For nonword sounds, we were able to identify 34 distinct vocalizations (see Appendix A). Nonword sounds that were not distinct were assigned to either "other one-note whistle" (MWH) or "other nonwhistle sound" (NWM). For all transcriptions, we omitted the first and last 2 min from analysis to control for any abnormal vocal behavior immediately before and after Cosmo's separation from B.J. and immediately prior to B.J.'s return. In addition, because B.J. occasionally inadvertently violated the experimental design rules during a given taping session (e.g., by

leaving the room during an IN session), the analysis only included the transcriptions from times that were in accordance with the social context being videotaped. For any sections of transcriptions that were not included, the 2 min before and after those sections were also omitted. The complete raw data set included 180 min in each context.

An independent observer transcribed 8 min each from the AL, IN, and OUT contexts (24 min total; 13% of the data set). The 8-min segments comprised four random selections of 2 consecutive min where at least 10 lines of vocalizations occurred. This criterion could not be met for the CO condition, explaining its exclusion from reliability coding. The range of Cohen's kappa coefficients for matching individual words/nonword sounds by the two transcribers was .65–.97 ($Mdn = .80$).

Data Analysis

A file-splitting program split each transcription into separate text files according to speaker. We compiled the Cosmo text files to create one large "Cosmo corpus" that could be divided according to social context.

Initial review showed that many individual words were only vocalized in conjunction with others, and that Cosmo's repertoire might be composed of both individual words as well as multivocalization phrases. Thus, to determine Cosmo's repertoire more accurately, the SAE Phrase Frequency Tool (Strategic Analysis Enterprises, Inc., Williamsburg, VA) computer program searched for recurrent phrases, as well as single words. This program is used by linguists to find recurrent phrases in text. The program tabulated the occurrences of all words and phrases ranging from one to nine words in length (nonword sound codes were tabulated as words) that occurred at least twice. Vocalizations that occurred only once were not tabulated because they could not be compared across contexts. If a phrase occurred only as part of a larger phrase (e.g., "in a car" was only ever uttered as "go in a car"), the program tabulated the larger of the two phrases.

With the resulting frequency of use data set for individual words and phrases, the AntConc (Version 3.2.1w, Laurence Anthony, Waseda University, Tokyo) freeware program determined the frequency with which each of the possible repertoire units occurred without being preceded or followed by other vocalizations. For example, the phrase "bad bird" was uttered 6 times, but was vocalized twice discretely. Thus, "bad bird" was counted as a unit in Cosmo's repertoire. If a single utterance or multiutterance phrase occurred only 1 time on its own, it was not included because of an inability to compare across contexts. Also, vocalization strings that had IDs in them were excluded. Those words, nonword sounds, and phrases that remained were considered to be units in Cosmo's vocal repertoire. The SAE Phrase Frequency Tool and AntConc programs were used to determine the frequency of use for all units in each social context separately so that chi-square analyses could be conducted to evaluate differences in the utterance rates and vocabulary richness across contexts.

Based on preliminary review of the unprocessed Cosmo corpus, we identified six salient themes to pursue in detail. These themes contained units that, in English, were solicitations for vocal interaction, requests for objects, requests to be taken out of the cage, requests for physical interaction, requests to go to a different location in the house, and references to Cosmo or B.J.'s spatial location. We categorized applicable units and recorded summed frequencies of use for each social context. An independent observer also categorized the units. The Cohen's kappa coefficient of reliability for matching categorization of the units was .91.

We calculated the percentage of repertoire units used per theme in each context. For example, if Cosmo used 14 units of the 29 that had been categorized as "vocal interaction," the vocabulary richness for that context was 48%. We also calculated the proportional rate of use of units in a given theme out of the total rate of all units that had been coded in that context. For example, if 300 utterances were categorized as "vocal interaction," this was calculated into a percentage of the total unit frequency in that context. Chi-square tests determined whether the units were nonrandomly distributed across the four contexts. These tests were performed only for themes with 20 or more cases across the four contexts (so that expected cell frequencies would be greater than or equal to 5). The alpha criterion used to reject the null hypotheses for all statistical tests was $p < .05$.

Results

Complete Repertoire

We used all of Cosmo's transcribed vocalizations from 720 min (180 min/context) of analyzable video footage. Linguistic analysis revealed that Cosmo's complete repertoire comprised 278 different units that ranged in length from one to eight words or nonword sounds (see Appendix B for complete repertoire). Cosmo used the 278 units 5,006 times in the data set.

As shown in Table 1, the repertoire contained 23 units that were classified as combinations (i.e., one or more English words with one or more nonword sounds), 36 units that were one or more nonword sounds, and 219 that were English speech units. Under most circumstances, the nonword sounds used in combination units were appropriate according either to the English content with which they were associated (e.g., "Betty kiss KS [kiss sound]," and "Cosmo wanna whi DUW [duet whistle]") or the situation in which Cosmo may have heard B.J. saying them (e.g., "OU ["oww" pain sound] don't bite," and "OOO ["oooh" o͞o sound as in "yoo"] what a bird"). "Good byelove you," "heygov," and "what's bach" were the only English units that contained gibberish.[1] Furthermore, "yoohoo," "oh," and "aww" were classified as English-only units given their unique value to the English language. It is interesting that a high degree of similarity existed among many of the units in both their English meaning (e.g., "Cosmo go up," "Cosmo wanna go up," "okay go up," and "wanna go up") and their grammatical structure (e.g., "we're gonna go for a walk" and "we're gonna go for walk").

English units represented 79% of the repertoire, although the frequency with which they were uttered constituted only slightly over one third of all vocalizations. In contrast, nonword units represented only 13% of the repertoire's units but 62% of the total number of utterances, indicating that Cosmo vocalized nonword units with a greater frequency than English units (see Table 1).

[1] Cosmo's utterance "What's bach" may be related to Pepperberg's (1999) note that Alex often pronounced *box* as *bock*. A review of our videotapes indicated that B.J. did label a box for Cosmo during one session.

Table 1
Number of Units and Rate of Use in Full Repertoire

Unit type	No. units	Rate
English	219 (78.8)	1,835 (36.7)
Nonword	36 (12.9)	3,086 (61.6)
Combination	23 (8.3)	85 (1.7)

Note. Total number of units = 278. Total rate of use = 5,006. Percentage of total is denoted in parentheses. "Combination" units contained at least one English word and one nonword sound.

Ranking the units according to frequency of use, the 20 most frequently vocalized units were 14 nonword units and six English units. These 20 units made up almost two thirds of the entire corpus content. The first English unit ("I'm here") was ranked eighth, further emphasizing nonword units as Cosmo's "preferred" class of vocalization. During transcription, notes were made suggesting that some nonword units were being used for communicative purposes between Cosmo and B.J. rather than simply as arbitrary sounds. Specifically, Cosmo and B.J. often vocalized wolf whistles, whistle melodies, and kiss sounds in a turn-taking fashion.

Context Differences in Frequency of Use and Vocabulary Richness

In context AL, Cosmo vocalized slightly more frequently than when B.J. was in the room with her. In contrast, Cosmo vocalized almost twice as much when B.J. was out of the room than in AL and IN. When B.J. ignored Cosmo in favor of interacting with the experimenter, Cosmo vocalized much less than in all of the other contexts. These data are quantified in Table 2. A follow-up analysis showed that in context CO, Cosmo's vocal behavior decreased across time; for the last 33 min of the third session and first 17 min of the fourth and final CO session, Cosmo did not vocalize, suggesting that there was a learning curve for being ignored.

The rates of vocalization were significantly different across all four contexts, $\chi^2(3, N = 5{,}006) = 1911.47, p < .001$. The number of repertoire units that Cosmo used also differed across all four contexts. That is, the size of Cosmo's "vocabulary" was, in fact, different across context, $\chi^2(3, N = 523) = 40.98, p < .001$.

The 10 most frequently vocalized units and their associated rate of use for each of the social contexts are shown in Table 3. For contexts AL, IN, and OUT, the use of nonword sounds was predominant (comprising 90%, 80%, and 80% of each of the lists, respectively). Conversely, nonword vocalizations were only 20% of the top-10 list when B.J. was ignoring Cosmo in favor of speaking to company.

The duet whistle was ranked first in both the IN and OUT contexts. Although B.J. was in the room in the CO context, the duet whistle did not appear in the top-10 list or even in the full list of units used in that context. Unlike in contexts AL and OUT, the use of nonword units dog bark, dog whine, and phone beep were not in the top-10 lists for the two social contexts when B.J. was in the room with Cosmo. Similarly, IN and CO were the only contexts with requests to approach ("wanna come here" and "come here," respectively) in their top-10 lists of most frequently uttered units. Considering frequency rather than actual units used, this indicates that the use of the nonword sounds in each context's top-10 list was very high (96%, 86%, 90%, and 76%, respectively, for AL, IN, OUT, and CO). Overall, Cosmo used nonword units approximately twice as frequently as English units in all four contexts except IN (see Table 4).

Thematic Differences Across Context

The six theme-related units made up 11% of Cosmo's total vocalizations in the AL context, 41% in IN, 34% in OUT, and 8% in CO. For vocal interaction, 29 units were categorized, including asking to kiss, whistle, or talk, as well as DUW, wolf whistle (WW), and all variations of KS. There were contextual differences in the relative amount with which Cosmo vocalized about this theme (see Figure 1). In contexts when B.J. reciprocated interaction, Cosmo's rate of vocalizing about vocal interaction was much higher, IN = 27% and OUT = 19%, than in the other two contexts. Wide variation existed across contexts in vocabulary richness (see Figure 2). Cosmo used 93% of the vocal interaction units in context IN. This dropped to 45% in OUT, 28% in AL, and 0% in CO. Thus, Cosmo's vocabulary about vocal interaction was the richest and the content of her speech most frequently referenced this theme during the IN context.

Ten units were categorized as requests for objects (e.g., grapes, peanuts, shower, and water). There was little variation across AL, IN, OUT, and CO in the relative unit frequencies for this theme (2%, 1%, < 1%, and 1%, respectively). Similar to vocal interaction, her vocabulary about requesting objects was the richest in the IN context, where she used 70% of the categorized units. Half of the units were used in AL, 40% in OUT, and 10% in CO.

Nineteen units were categorized as requests by Cosmo to be taken out of her cage, including "here step up," "wanna go up," and "be a good bird okay go up." The IN context had the highest rate of use (5%) of this theme's units. Cosmo's vocabulary was the richest (90%) when B.J. was in the room and vocalizing with her.

Eight units were categorized as requests for physical interaction, including "come here please," "Cosmo wanna cuddle," and "wanna come." This theme was the only one in which CO's percentage of total frequency of use (7%) was higher than in the other three social contexts. With respect to vocabulary richness, all eight of the units were used in the IN context, followed by OUT (75%), CO (50%), and AL (25%).

Eleven units were categorized as requests to go to a different location within the house, including going to the kitchen, going to "Betty Jean room," and going back in Cosmo's cage. Even in the OUT context, the frequency with which Cosmo requested to go to a new location was less than 1% across all contexts. With the exception of CO, during which no requests to move to a different

Table 2
Number of Units and Rate of Use Across Social Contexts

Social context	No. units*	Rate*
Alone	145	1,336
In	187	1,324
Out	171	2,261
Company	20	85

* $p < .001$.

Table 3
Most Frequently Vocalized Units Across Social Contexts

Rank	Alone	In	Out	Company
1	NWM (205)	DUW (135)	DUW (353)	NWM (55)
2	DS (150)	NWM (122)	WBI (307)	Wanna be a good bird (4)
3	WBI (128)	KS (76)	NWM (1679)	Wanna cuddle (3)
4	DW (69)	No (56)	DS (160)	Cos don't bite okay (2)
5	PH (66)	WBI (37)	I'm here (102)	Cosmo wanna be a good bird (2)
6	OOO (35)	OOO (34)	MWH (81)	Don't bite okay (2)
7	DUW (31)	MWH (29)	PH (79)	No peanut (2)
8	Hello (29)	Wanna come here (22)	DO (54)	Okay (2)
9	RI (28)	WF (22)	DW (49)	WBI (2)
10	MWH (22)	KS KS (19)	I love you (46)	Come here (1)

Note. Rate of use for each unit is denoted in parentheses. NWM = other nonwhistle sound; DUW = duet whistle; DS = dog bark, gruff, or howl; WBI = wild songbird vocalization; KS = kiss; DW = dog whimper; PH = telephone dial beep; OOO = "oooh" (o͞o sound as in "yoo"); MWH = other one-note whistle; DO = door opening creak; RI = telephone ring; WF = "woo-woo-woo" or "woo" (B.J.'s imitation of a dog). Refer to Appendix A for full coding scheme.

location were made, vocabulary richness for the theme was comparable across contexts (AL = 36%, IN = 46%, and OUT = 55%).

Twelve units referred to either Cosmo's or B.J.'s spatial location, including "DUW I'm here," "here I are," "I'm here," and "where are you." Only 1% and 2% of AL and IN's respective total frequencies referenced this theme, and this percentage dropped to zero in CO. The OUT context had the highest percentage (10%). The richest vocabulary was also in the OUT condition (83%). These percentages were greatly reduced in the AL (42%), IN (33%), and CO (0%) contexts.

Discussion

This study demonstrates that features of a home-raised African Grey parrot's spontaneous vocal production changed significantly across different social situations. Three key observations from the data lead us to the conclusion that Cosmo's vocal production is largely affected the presence and responsiveness of the social partners in her environment (i.e., social context).

First, the distribution of nonword units across the contexts was not equal. Cosmo used English units more frequently than nonword units when B.J. was in the room with her and reciprocated her vocalizations. Conversely, in the AL and CO contexts, Cosmo used nonword units more than English units. We believe that a majority of the nonword units in Cosmo's repertoire neither require nor promote reciprocated interaction, which may explain why they were used so frequently in these contexts. Furthermore, in the unfamiliar situation of being ignored, Cosmo used a greater variety of English units than nonword units. Thus, B.J.'s presence in the room but lack of reciprocation was associated with an increase in Cosmo's persistence in using speech but a decrease in the repetition of any one speech unit (as evidenced by multiple units that were only once or twice each). We interpret this as after multiple failed attempts to solicit interaction from B.J. using speech, Cosmo treated being ignored as being alone and vocalized with nonword units more frequently than she would have if B.J. had reciprocated interaction.

Second, the distribution of "neutral" vocalizations went against what learning through associative processes would predict. Based on principles of associative learning, we might expect that Cosmo would hone her vocal production in varying social situations to include only contextually appropriate aspects of her repertoire. That is, those units reinforced by responses from B.J. would be more likely to be repeated (e.g., "Cosmo wanna kiss" during the IN context), whereas those that were not would be less likely to be repeated (e.g., dog barks during the IN context). If this were true, over time Cosmo's vocabulary would be expected to change as a function of social context. However, as described above with

Table 4
Unit Type Frequencies Across Social Contexts

	Unit type		
Social context	English	Nonword	Combination
Alone	419	907	10
In	700	586	38
Out	689	1,535	37
Company	27	58	0

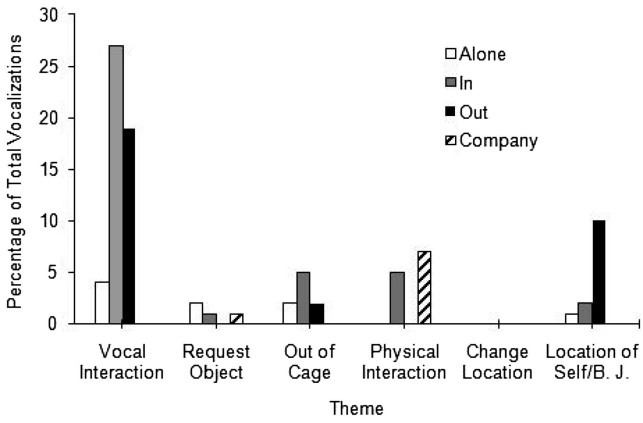

Figure 1. Rate of use of themed units across social context. Bars show the percentage of the total vocalizations represented by each theme. Units related to going to a different location represented < 1% of the total vocalizations for all contexts.

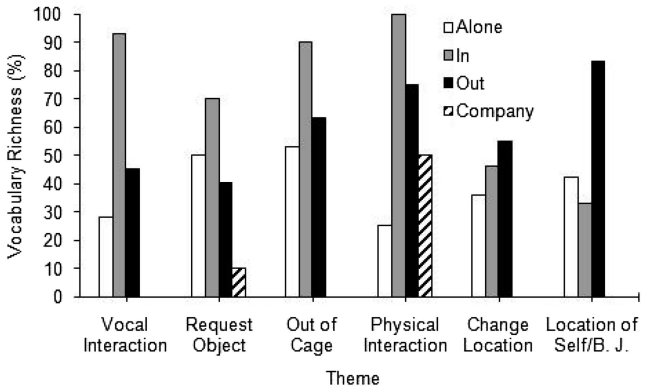

Figure 2. Vocabulary richness for themed units across social contexts. Bars represent the percentage of units used out of the total number of units categorized in a given theme.

nonword sounds, this is not what we found. For example, B.J.'s telephone rings and her dogs vocalize independent of social context, but Cosmo produced these sounds most often during the two contexts when B.J. was not in the room (i.e., AL and OUT contexts). When B.J. was available to reciprocate, Cosmo produced these neutral units less frequently, further supporting the conclusion that Cosmo actively monitors her social environment.

Third, the thematic content of Cosmo's vocalizations varied depending on the social context. We identified six themes in the corpus: references to vocal interaction, requests for objects, requests to get out of the cage, requests for physical interaction, requests to go to a new location within the house, and references to Cosmo's or B.J.'s spatial location. We addressed Cosmo's understanding of the use of themes insofar as she had learned that vocalizing with certain units was associated with a particular outcome. That is, we assumed that when she asked for a grape or for B.J. to approach her cage, she was deliberately communicating with the appropriate units with the expectation of that unit's previous, repeatedly associated outcome. Cosmo produced higher proportions of units from the vocal interaction theme when B.J. reciprocated (i.e., IN and OUT contexts) than when she did not (AL and CO contexts). Furthermore, Cosmo used units associated with vocal and physical interaction, requests, and references to her spatial location and that of B.J. with a higher frequency during the IN and OUT contexts than during the AL and CO contexts. In AL and CO, Cosmo vocalized more often about nontheme content (e.g., "that's squirrel," hawk imitations, and dog barks) than theme content. Taken together, the above observations are indicators that Cosmo's vocal production is far from random and is strongly influenced by the context created by variations in her social partner's physical presence and willingness to reciprocate interaction.

There is a possibility that B.J. only uses certain themed units during certain contexts such that Cosmo associates their use with those contexts. For example, B.J. rarely says, "Where are you?" unless she and Cosmo are in separate rooms. After many years of experience, one might expect Cosmo's vocalizations to have little contextual overlap. However, our results show that Cosmo makes contextually inappropriate utterances (such as asking for objects while alone). Although her motives for making these vocalizations are unclear, Cosmo may have been practicing new words. An investigation of the loudness and clarity with which she vocalizes these contextually nonrelevant utterances versus others may provide answers.

Another point to consider is the surprisingly low rate with which Cosmo vocalized during the CO context. Given Cosmo's strongly bonded relationship with B.J., we expected vocal competition for B.J.'s attention. According to B.J. (personal communication, June 2, 2008), she and her human company rarely ignore Cosmo. Although unfamiliarity with the experimenter and the novel social context of being ignored no doubt affected Cosmo's vocal production, our learning curve data suggest that part of her silence can be attributed to her learning that she was being ignored. It is interesting that Cosmo requested physical interaction proportionally more often in the CO context than in any other. We interpret this as Cosmo making some distinction between which modality of interaction works and which does not in a given situation. Specifically, when Cosmo recognized that her preferred vocal method of interaction was not possible, she compensated by requesting more physical interaction. This is an important finding because it shows that Cosmo first monitors who is in the room and what they are doing, and then modifies the content of her vocalizations in strategic ways to achieve the best possible method of maintaining social contact with her intended partner.

Our main content prediction was that Cosmo would be more likely to use units that, in English, reference her own spatial location and that of B.J. during times of visual separation. The data support this prediction, as evidenced by the differences across the contexts in the relative rate of vocalizing and vocabulary richness for that theme. Furthermore, Cosmo typically uttered the spatial location units with an amplified voice (like B.J.'s), and the vocalizations were persistent, repetitive, and frequently solicited vocal duetting with B.J., which mirrors the features of a wild contact call (Nottebohm, 1972; Thorpe & North, 1966; Wickler & Seibt, 1980). Thus, as we predicted, Cosmo appears to have flexibly developed a functionally equivalent adaptation of the contact call using speech and species-atypical vocalizations.

Although Cosmo is only one parrot, our results demonstrate for the first time that it is within the abilities of a nonhuman, nonprimate, nonmammal species that has been raised with a responsive human conversational partner in a home rather than a lab to use a variety of speech and nonword sounds in a deliberate, contextually relevant fashion. Moreover, despite the fact that Cosmo was not explicitly taught the vocalizations that she uses to communicate with B.J. (in contrast to many of the words produced by lab-reared parrots), she has still developed more than a surface, auditory-based understanding of the units in her repertoire. That is, she has picked up how to produce numerous utterances in an arguably context-appropriate manner. Our findings stress the important role that socialization plays in learning to communicate. They also suggest that a primate, or even mammalian, brain may not be necessary for an individual to develop aspects of vocal communicative competence.

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Appendix A

Coding Scheme for Nonword Sounds

Code	Description	Code	Description
AM	Answering machine beep	LS	Laser sound
CR	Crow caw	LSW	Laser sound-ID-whistle combination
DS	Any dog bark, gruff, or howl	MWH	Other one-note whistle
DSS	Any dog bark, gruff, or howl sequence	NWM	Other non-whistle sound
DO	Door opening creak	NWMS	Other non-whistle sequence
DOS	Door opening creak sequence	OOO	"Oooh" (ōō sound as in "yoo")
DUW	Duet whistle	OU	"Oww" (as in pain)
DUWS	Duet whistle sequence	OW	Owl hoot
DW	Dog whine/whimper	PH	Telephone dialing beep
DWS	Dog whine/whimper sequence	PHS	More than five telephone dialing beeps
FR	Frog croak	RI	Telephone ring
HA	Hawk cry	RIS	Telephone ring sequence
HAS	Hawk cry sequence	WBI	Wild songbird vocalization
ID	Indistinguishable	WBIS	Wild songbird vocalization sequence
KS	Kiss sound	WF	"Woo-woo-woo" or "woo" (B.J.'s imitation of a dog)
KSS	Kiss sequence	WW	Wolf whistle
LA	Laugh	WWS	Wolf whistle sequence

Note. "Sequence" denotes vocalization that was repeatedly uttered for more than 4 s. "Duet whistle" was a melodic whistling, not natural bird vocalization.

(*Appendices continue*)

Appendix B

Cosmo's Complete Repertoire With Rates of Use (See Appendix A for Coding Definitions)

Vocalization	Rate	Vocalization	Rate
NWM	561	DUW I'm here	12
DUW	519	Go up	12
WBI	474	Hello Cosmo	12
DS	316	LSW	12
PH	157	Mary	12
MWH	133	Okay go up	12
DW	122	Wanna cuddle	12
I'm here	115	You have reached	12
KS	108	Cosmo wanna water	11
OOO	87	KS KS KS	11
WF	78	Wanna kiss	11
No	75	WBIS	11
DO	70	We're gonna have company	11
Okay	67	Where are you	11
I love you	66	Betty Jean wanna kiss	10
Hello	55	Betty Jean kiss	10
LS	53	Come here please	10
RI	50	Cosmo don't bite okay	10
WW	48	Cosmo wanna cuddle	10
Here you are	47	Doggies wanna go for a walk	10
Goodbye	43	DOS	10
There you are	41	KSS	10
How are you	40	That's bark	10
LA	40	OU	9
CR	36	That's tele	9
PHS	36	Want kiss	9
Hi	34	Wow	9
What's that	33	Aww	8
Hi Tom	29	Fine thanks how are you	8
Come here	26	Squirrel	8
Wanna come here	26	Telephone	8
Wanna be a good bird	25	What	8
KS KS	23	What that	8
DSS wanna go up	22	Bark	7
Cosmo	21	Come on	7
Cosmo wanna talk	21	Cosmo poop	7
DWS	21	Don't bite	7
HA	21	FR	7
Let go	20	Hello Kerri	7
Here I are	19	Kiss	7
What's bach	19	Mary has feathers	7
Please	18	Oh goodbye	7
That's squirrel	18	Okay goodbye	7
Wanna peanut	18	Step up	7
We're gonna go for a walk	18	You have reached Betty Jean	7
AM	17	Cos	6
That's birdie	17	KS KS KS KS	6
Cosmo	15	Okay we're gonna go for a walk	6
What a bird	15	That's beak	6
Cosmo wanna be a good bird	14	That's rain	6
Here step up	14	Wanna be a bird	6
That's WF	14	Wanna come	6
Cosmo go up	13	We're gonna have	6
Fine thank you	13	Bark WF	5
Look for bird	13	Cosmo wanna kiss	5
Telephone	13	Don't bite okay	5
That's televi	13	No peanut	5

(*Appendices continue*)

Appendix B (*continued*)

Vocalization	Rate	Vocalization	Rate
What's bye	13	Step up here	5
Cosmo be a good bird	12	That's	5
That's bark WF	5	Mary has	3
Wanna go up	5	No more peanut	3
Wanna talk	5	Oh	3
We'll be back soon	5	Okay Cosmo	3
What a good bird	5	Okay step up	3
What's bark	5	Peanut's in cage	3
Be back soon be back	4	Tel for bird	3
Betty Jean have go in a car	4	Televi	3
Cos don't bite okay	4	That's bye	3
Cosmo don't bite	4	That's doggie bark	3
Cosmo has feathers MWH	4	That's wanna grape	3
Cosmo has feet	4	That's water	3
Cosmo wanna	4	Wanna go back cage	3
Cosmo wanna be a bird	4	Wanna go to bed	3
Cosmo wanna go for a walk	4	Wanna go up here	3
Cosmo wanna go to bed	4	Want kiss KS KS KS	3
Cosmo wanna shower	4	Want peanut	3
Cosmo wanna whi DUW	4	We'll be back	3
Cosmo's a birdie	4	Bad bird	2
Fine	4	Betty go in a car	2
Go up here	4	Betty kiss KS	2
Here step up here	4	Bye	2
Hi Tom how are you	4	Cos don't bite	2
Let go please	4	Cosmo and Betty Jean wanna whistle	2
Mary has feathers MWH	4	Cosmo back in cage	2
NWMS	4	Cosmo be a go up	2
Okay bye	4	Cosmo Betty Jean have go in a car	2
OW	4	Cosmo go up here	2
Thank you	4	Cosmo has feathers	2
That's Cosmo	4	Cosmo LA	2
That's doggie	4	Cosmo please	2
Wanna	4	Cosmo wanna go back cage	2
Wanna be a	4	Cosmo wanna peanut	2
Wanna be a good	4	Cosmo wanna whistle	2
Wanna whistle	4	Cosmo we're gonna go in a car	2
We'll be back soon be back	4	Cosmo's a good good bird	2
We're gonna go	4	Doggie bark	2
WWS	4	Good byelove you	2
Be a good bird okay go up	3	HA	2
Betty Jean have	3	HAS	2
Betty Jean have to go in a car	3	Hello Kaylee	2
Betty Jean have to leave	3	Here	2
Betty Jean wanna	3	Here I	2
Betty Jean wanna kiss KS	3	Here you are here	2
Come Mary	3	How are thank you	2
Cosmo go back cage	3	I wanna kiss okay	2
Cosmo wanna come here	3	Kiss okay	2
Cosmo wanna go to kitchen	3	KS KS KS KS KS KS	2
Cosmo wanna go up here	3	Let's go to Betty Jean room	2
Cosmo's a bird	3	Look Cosmo	2
[First three digits of B.J's phone number]	3	Mary come on	2
[Seven digits of B.J.'s phone number]	3	No Cos	2
Good kiss	3	Oh thank you bye	2
Goodbye Kerri	3	Okay come here	2
Heygov	3	Okay	2
Hi Cosmo	3	Okay dogs we're gonna go for a walk	2
Hi Tom LA	3	Okay goodbye NWM	2

(*Appendices continue*)

Appendix B (*continued*)

Vocalization	Rate	Vocalization	Rate
I love	3	Okay let's go to kitchen	2
I love you KS	3	Okay time for shower peanut	2
Let go LA	3	OOO what a bird	2
OU don't bite	2	Wanna go for a walk	2
Peanut	2	Wanna go to	2
Peanut in cage	2	Wanna go to kitchen	2
Please step up	2	Wanna kiss KS KS	2
S (*s* sound)	2	Wanna kiss KSS	2
Step up please	2	Wanna peanut okay	2
Tele for Betty Jean	2	Wanna shower and peanut	2
Tele for bird	2	Wanna step up	2
Telephone for	2	Wanna whi DUW	2
Thank	2	We're	2
Thanks bye PH	2	We're gonna go for walk	2
That's Cosmo's a birdie	2	We're gonna go in a car	2
That's doggie has	2	What a good	2
That's kiss	2	What's	2
That's paper	2	Where Cosmo	2
That's poop	2	Why thank	2
That's wanna water	2	Wow LA	2
There you	2	Yoohoo	2
Time	2	You have reached Cosmo	2
Wan go to bed	2	You LA	2

Received February 16, 2010
Revision received October 18, 2010
Accepted November 1, 2010 ■