AN AFRICAN GREY PARROT'S VOCAL PRODUCTION VARIES ACROSS SOCIAL

CONTEXT

by

ERIN NATANNIE COLBERT-WHITE

(Under the Direction of Dorothy M. Fragaszy)

ABSTRACT

Hand-reared African Grey parrots exhibit strong social bonding with their human companions. This experiment examined how one parrot's vocalizations changed across social context with respect to measures of unit use and content. The subject was videotaped in four social contexts: subject home alone, subject with owner in the room, owner in separate room within hearing range, and owner and experimenter conversing in the same room as subject but ignoring her. Linguistic analysis revealed the subject's repertoire was 278 units ranging 1-8 words long. Total unit frequency and vocabulary richness (i.e., number of different units used) differed significantly, along with the rankings of the repertoire's most commonly used units, suggesting the vocalization content differed across context. The subject referred to her own spatial location and that of her owner most frequently in the out of room context, suggesting an adaptation of the wild parrot contact call.

INDEX WORDS: African Grey parrot, vocalization, speech, vocal behavior, social context, contact call

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DEDICATION

To my mother, Pamela White, for making sure I never brought home a C, and to my research mentor, Dr. Cody Brooks, for reminding me to breathe when necessary.

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SECTION 1

INTRODUCTION

The current research investigates the vocal production (i.e., speech and non-word vocalizations) of a Congo African Grey parrot (*Psittacus erithacus erithacus*). 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). Cases of non-human animals using speech are restricted to a few rare instances in great apes and to some avian species (Pepperberg, 1999; Friend, 2004). I aim to show that features of one African Grey parrot's spontaneous vocalizations (speech and non-word sounds) differ across social context, suggesting evidence for functional use.

Aspects of psittaciforms' natural history make them exceptionally interesting candidates with which to study vocal behavior in social settings. Little is known about the natural history of African Grey parrots, but behavior across species in the parrot family is generally similar. Psittaciforms are reproductively monogamous and highly affiliative with flockmates (Seibert, 2006). In several species, pair-bonded individuals prefer close physical contact with their mates (Spoon, 2006) and in at least one species, mating pairs engage in antiphonal duetting (Nottebohm, 1972). Many authors suggest that a majority of wild parrots' repertoires is learned through social experience with parents or other flockmates (Nottebohm, 1972; Bergman & Reinisch, 2006; Doupe & Kuhl, 1999), implicating social interaction as an important context for learning vocalizations. When visual barriers separate flockmates, many parrot species produce discrete sounds called "contact calls" (Bergman & Reinisch, 2006). The use of specific

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vocalizations to maintain social contact has also been documented in highly social mammalian species such as elephants, dolphins, and some non-human primates (McComb, Reby, Baker, Moss, & Sayialel, 2003; Watwood, Owen, Tyack, & Wells, 2005; Cheney & Seyfarth, 1996). Dunbar (2003) has suggested that language evolved in our human ancestors as a means of regulating and maintaining social cohesion among group members when physical proximity was not possible, a sort of social "grooming." Duetting by paired individuals in parrot species both strengthens social bonds and helps with the coordination of movement by the pair during times of minimal visibility (Nottebohm, 1972). Thus, the contact call for parrots may serve a function that is similar to Dunbar's notion of why language evolved in humans.

Language-learning in young children relies heavily on social interaction (Doupe & Kuhl, 1999) in a conversational context. Only a small body of literature describes non-human primate or ceteacean species engaging humans in "conversation" using artificial languages, signed languages, or vocal communication (Friend, 2004). Despite using the same (albeit differently aligned) vocal apparatus as humans, apes have demonstrated the ability to vocalize only up to five words (Hillix & Rumbaugh, 2004). Parrots, on the other hand, can produce many spoken words, as well as melodies and non-word sounds. Whether they engage their caregivers in conversation is an open question.

Well into the 1970s, vocal production by parrots was regarded as mimicry, that is to say, purposeless duplication that lacked high-level information processing (Tomasello & Carpenter, 2005; Pepperberg, 1999). Using a training method that required subjects to attend to multiple parts of a question in order to respond accurately, Irene Pepperberg provided compelling evidence that parrots are capable of using words referentially (Pepperberg, 2006; see Pepperberg, 1999 for review). Presented with two objects that differed in shape, color and/or material, her

subjects had to attend to the properties of the objects, consider what property the vocalized question concerned, determine the answer, then vocalize the response. In her paradigm, there was a low probability of answering correctly by chance. On a transfer test of the sameness/difference concept, one subject, Alex, scored 85% on presentations of items he had never seen before (Pepperberg, 1999), suggesting a flexible understanding of concepts.

With some exceptions, such as Pepperberg's (1991) investigation of self-speech, studies of parrots' use of speech focus on topics such as referential learning and numerical competence (Pepperberg, Gardiner, & Luttrell, 1999). These studies used experimental paradigms in a question-and-answer format with one person. We know from some studies that social interaction can play a significant role in parrots mastering concepts (e.g., sameness and difference of color, shape, and material properties) associated with cognitive tasks like label-learning (Pepperberg, 1994; Pepperberg et al., 1999). However, there is no empirical work concerning the effects of social interaction with humans on non-humans' spontaneous vocalizations. This study provides an initial systematic investigation of spontaneous vocalizations in a parrot across a range of social contexts.

Parrot natural history suggests that strong social bonding occurs between pairs of African Greys and between human caregivers and hand-reared African Greys (Nottebohm, 1972; Athan, 1993; Seibert, 2006). Hand-reared parrots often bond with their human caregivers and treat them like a conspecific pair-mate. If speech comes to replace or to be used in conjunction with species-typical vocalizations (Bergman & Reinisch, 2006), then I would expect that one function of spontaneous speech (and other discrete non-word vocalizations) is to maintain social contact. Thus, I predict that a linguistic analysis would provide evidence that the bird's vocalizations can serve the function of a contact call.

To assess how features of an African Grey parrot's spontaneous vocal production vary across social context, one parrot, Cosmo, was videotaped in each of four distinct social conditions: a) Cosmo alone in the house, b) Cosmo and owner together in the same room, c) Cosmo and owner in separate rooms within hearing range, and d) owner and "company" conversing together in the room with Cosmo but ignoring her. Comparisons were made across the four contexts for evidence of differences in measures of her vocal production.

If Cosmo uses vocalizations spontaneously to promote interaction and/or to maintain auditory contact with her human companion, she should vocalize differently when her human companion's physical presence and willingness to reciprocate interaction vary. Specifically, across context a) Cosmo should vocalize with different frequencies, b) Cosmo's vocabulary richness (i.e., the portion of her full repertoire that she uses) should be different, and c) differences should be apparent in the content of the vocalizations. That is, during periods of visual separation, Cosmo's vocal production will contain more vocalizations that, in English, refer to spatial location, request the owner to come in close proximity (i.e., back into the room where the parrot is confined), or induce the owner to vocalize. These vocalizations may be indicative of an adaptation of the wild parrot contact call.

SECTION 2

METHOD

Subject

Cosmo is a 7-year-old, female Congo African Grey parrot. She was hatched in Florida and transported to a pet-store at 5 months of age. Cosmo's female owner (B. J.) purchased her from the pet-store in 2002. While Cosmo has extensive experience hearing other human speakers, B. J. is her consistent companion, with the exception of one pet-sitter 2-3 times per year for approximately 3 days at a time while B. J. is out of town. According to B. J., she and Cosmo began taking turns whistling until Cosmo was 12-months-old at which time Cosmo began using words. B. J. uses simplified grammar and limited vocabulary to label new objects for Cosmo and to correct Cosmo's misuse and mispronunciation of words. Social interaction is the sole means by which Cosmo acquired melodies, English speech, and some non-word sounds like kiss noises.

Materials

All experimentation was conducted at B. J.'s home with Cosmo in her primary cage (55.9 x 61.0 x 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. Two walls of the room were large windows that overlooked a wooded area. Three weeks prior to initiation of data collection, a Sony DCR-TRV39 mini-DV video camera was positioned on a tripod 1.5 m from Cosmo's cage to allow her to habituate to the presence of 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. recorded sixty-minute sessions at her convenience from October 20, 2007 until August 12, 2008.

Experimental Procedure

Data were collected in four conditions, Cosmo alone in the house (AL), B. J. in the room with Cosmo (IN), B. J. in an adjacent room out of visual contact but within hearing range (OUT), and B. J. simulating conversation with the experimenter (E. C. W.) while ignoring Cosmo (CO). I asked B. J. to interact normally with Cosmo but to refrain from using the telephone or television during all taping. In the AL condition, B. J. began the video camera and left her house for the duration of the session. For the IN condition, B. J. sat 2 m away from Cosmo in the room with her and spoke with her as normal. In the OUT condition, B. J. remained in an adjacent room so that only vocal interaction with Cosmo was possible and spoke with her as normal. In the CO condition, E. C. W. and B. J. sat in the same room with Cosmo simulating dialogue by taking turns reading sentences from B. J.'s personal online blog, "Betty Dowdy's Diary." Throughout CO sessions, the experimenter and B. J. ignored Cosmo by refraining from interacting with her, talking about her, and making eye contact with or body gestures towards her. According to B. J. (personal communication, 2008), this was a highly unusual social context for Cosmo. All procedures were approved by the University of Georgia IACUC (Approval #A2007-10142).

Transcriptions and Coding

I digitized the videotapes using Adobe Premiere (Version 6.5; 32 kHz, 16-bit audio) and played them through The Observer XT (Version 6.1.40). All three speakers' vocalizations were transcribed in Microsoft Notepad. Transcriptions were typed in lowercase with a timestamp, denotation of speaker, and vocal content. All background sounds were omitted. As with Nelson's (1989) transcriptions of her child subject, I used subjective pause lengths between utterances to

segment the vocalizations by line. Often, two or more non-word vocalizations appeared on the same line if they occurred in close temporal proximity to each other. I phonetically transcribed syllables and fragments in a consistent manner (e.g., "tele" and "showe" for "telephone" and "shower," respectively). Cosmo's inaudible or questionable English vocalizations (for example, "beak" and "feet" were often difficult to distinguish) were coded similarly to Nelson's transcription of indistinguishable vocalizations. Instead of using question marks, I used the code "ID" for "indistinguishable." Depending upon the length of the 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 sometimes transcribed as "good byelove you"). With the exception of possible homophones (e.g., "that's rain" versus "that's reign"), contextual information was not used to construct transcriptions to avoid bias.

I developed a coding scheme for all non-word vocalizations by applying a two- or three-letter abbreviation to 36 different sounds (as shown in Table 1). Those vocalizations that were not easily labeled were placed in one of two miscellaneous classes of one-note whistles or non-whistle sounds. Early difficulty in distinguishing between vocalizations of bird sounds specific to parrots and those of wild songbird chirps resulted in the recoding of all bird sounds as wild bird sounds (see table). If the same non-word vocalization persisted for more than 4 seconds it was subsequently labeled as a "sequence."

Table 1 *Coding Scheme for Non-Word Sounds*

CODE	DESCRIPTION	CODE	DESCRIPTION
AM	Telephone answering machine beep	LS	Laser sound
CR	Crow caw	LSW	"Laser sound-ID-whistle" combination
DS	Any dog bark, gruff, or howl	MWH	Miscellaneous one-note whistle
DSS	Any dog bark, gruff, or howl sequence	NWM	Miscellaneous non-whistle
DO	Door opening creak	NWMS	Miscellaneous non-whistle sequence
DOS	Door opening creak sequence	OOO	"Ooh" and other long-*o* sounds
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 vocalization	RIS	Telephone ring sequence
HAS	Hawk vocalization sequence	WBI	Wild miscellaneous songbird
ID	Indistinguishable	WBIS	Wild miscellaneous songbird sequence
KS	Kiss sound	WF	"Woo-woo-woo" or "woo" (B. J.'s vocalization of a dog barking)
KSS	Kiss sound sequence	WW	Wolf whistle
LA	Laugh	WWS	Wolf whistle sequence

"Sequence" = Vocalization repeatedly uttered for more than 4 seconds. "Duet whistle" = Melodic whistling, not natural bird vocalization.

For all transcriptions, I omitted the first and last 2 minutes 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 to be included, the 2 minutes before and after were also omitted. The complete dataset included 180 minutes of usable recording for each context (see Appendix A for an excerpt from a transcription).

From the data files, an independent observer transcribed 8 minutes in each condition. The 8 minutes were four selections of two consecutive minutes where at least 10 lines of vocalizations occurred. The mean Cohen's kappa coefficient of reliability was $\kappa = .80$.

Data Analysis

A file-splitting computer program prepared the raw data for analysis. The program split each transcription into separate transcription files according to speaker, and used the timestamps to calculate small (5-10 s), medium (10-20 s), and large (> 20 s) pauses between an individual's vocalizations. All subsequent analyses used the Cosmo corpus.

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 multi-word 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, and not only single words. This program is used by linguists to find recurrent phrases in text. The program tabulated the number of occurrences of all words and phrases ranging one and nine words long (non-word sounds were tabulated as words) that occurred at least two times. Not tabulated were any words and phrases that only occurred once due to the inability to make later comparisons across conditions. If a phrase only occurred as part of a larger phrase (e.g., "in a car" was only uttered as "go in a car"), then the program tabulated the larger of the two phrases. Phrases were not included if they contained or spanned periods.

With the resulting phrase frequency table of individual words and phrases, the AntConc (Version 3.2.1w) freeware program determined the frequency with which each of the possible repertoire units occurred discretely. For example, the phrase "bad bird" occurred six times, but was vocalized twice discretely. Thus, "bad bird" was a unit in Cosmo's repertoire. If a single

word or multi-word phrase only occurred one time on its own, it was not included in the analysis because again, comparisons across conditions were not possible. Also, units that had IDs in them were excluded. Those units that remained were considered to be Cosmo's full repertoire (see Appendix B).

The SAE Phrase Frequency Tool and AntConc programs determined the frequency of use for all units in each social condition separately. Unlike with the full repertoire, phrases that occurred only once on their own in a condition were included for the purpose of determining if some units were vocalized in one condition but not others. Chi-square analyses looked for differences in the total utterance frequency as well as vocabulary richness in each of the four conditions.

Using the complete repertoire's 40 most frequently used units, a rank order was established for each social condition. For example, miscellaneous non-whistle (NWM) was the highest ranked unit in the full repertoire, and appeared in positions 1, 2, 3, and 1 for AL, IN, OUT, and CO, respectively. I ran Spearman's *rho* correlations for each pair of conditions and for each condition with the full repertoire to evaluate similarities among the four conditions in how the full repertoire's most frequently used units were ranked.

Based on preliminary review of the unprocessed corpus, I identified six of the most salient themes for more detailed analysis: vocal interaction, requests for objects, requests to get out of the cage, requests for physical interaction, requests to move to a new location within the house, and units referencing Cosmo or B. J.'s spatial location. Units were categorized appropriately (see Appendix C), and summed frequencies were recorded for the full repertoire, as well as for each of the four social conditions. An outside observer also categorized the units. The Cohen's kappa coefficient of reliability was $\kappa = .91$. Chi-square tests calculated whether the

units were non-randomly distributed across the four conditions. These tests were only performed

when the ns for all social conditions' were greater than or equal to 20. The alpha criterion used to

reject the null hypotheses for all statistical tests was $p < .05$.

SECTION 3

RESULTS

Complete Repertoire

I used all of Cosmo's transcribed vocalizations from 720 minutes (180 per condition) of analyzable video footage. Linguistic analysis revealed that Cosmo's complete repertoire was made up of 278 different non-word sound units and English units which ranged in length from 1-8 words. Cosmo used the 278 units a total of 5,006 times in the dataset. Twenty-three of the 278 units contained a combination of one or multiple English utterances and one or multiple non-word units. Thirty-six were non-word units consisting of one or multiple non-word labels.

Because all English sounds and English syllables were transcribed, the SAE Phrase Frequency Tool recognized the *s* sound, which appeared twice on its own, as a unit. Other word fragments recognized as units included "cosmo wanna whi DUW (duet whistle)," "tel for bird," "tele for betty jean," "tele for bird," "televi," "that's tele," "that's televi," "wan go to bed," and "wanna whi DUW." With the exception of the two units containing DUWs, the *s* sound and fragment units were all categorized as English-only units.

Including those units described above, the repertoire contained 219 English-only units. Three English units, "good byelove you," "heygov," and "what's bach," contained gibberish that were consistently uttered and so were transcribed as such. This could be similar to Pepperberg's (1991) note that Alex mispronounced "box" as "bach." A review of Cosmo's video tapes indicated B. J. labeled a box for Cosmo during one session. English words associated with sounds, specifically "yoohoo," "oh," and "aww," were transcribed and analyzed as English-only

units due to their unique emotional value in the English language. A high degree of similarity existed among the units in both their concept (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-only units represented 79% of the repertoire, although the frequency with which they were used constituted only slightly over one-third of all vocalizations. In contrast, non-word units represented only 13% of the repertoire, but 62% of the total frequency, suggesting Cosmo vocalized with non-word units with a greater frequency than English-only units. These data are shown in Table 2. Ranking the units according to frequency of usage, the 20 most frequently vocalized units were 14 non-word units and 6 English-only units (see Table 3). The first English-only unit ("i'm here") did not appear on the list until the eighth rank, further emphasizing non-word units as Cosmo's preferred class of vocalization. In comparison to the rest of the repertoire, the top 20 units comprised almost two-thirds of the entire unit frequency total.

Table 2 *Number of Units and Associated Frequencies for Each Type of Unit in Cosmo's Repertoire*

UNIT TYPE	NUMBER	FREQUENCY
English only	219 (78.8%)	1,835 (36.7%)
Non-word	36 (12.9%)	3,086 (61.6%)
English with non-word	23 (8.3%)	85 (1.7%)
Total number of units is 278; total unit frequency is 5,006. Percent of total is represented in parenthesis.		

Table 3 *Twenty Most Frequently Used Units in Cosmo's Repertoire*

FREQ.	UNIT
561	NWM
519	DUW
474	WBI
316	DS
157	PH
133	MWH
122	DW
115	i'm here
108	KS
87	OOO
78	WF
75	no
70	DO
67	okay
66	i love you
55	hello
53	LS
50	RI
48	WW
47	here you are

"Freq." = Frequency.

Under most circumstances, the non-word sounds used in combination English with non-word units were contextually appropriate according either to the English content with which they were associated (e.g., "bark WF [B. J. bark sound]," "betty kiss KS [kiss sound]," and "cosmo wanna whi DUW") or the condition under which Cosmo may have heard B. J. saying them (e.g., "cosmo LA [laugh]," "OU [pain ouch sound] don't bite," and "OOO [ooh sound] what a bird"). Similar to the human speech articulation distortion where *s* sounds are sometimes vocalized as whistles, half of the units containing the word *feathers* were accompanied by a miscellaneous one-note whistle (MWH), as in "cosmo has feathers MWH."

During transcription, notes were made suggesting that some non-word units were being used for communicative purposes between Cosmo and B. J. rather than simply as arbitrary sounds. They often vocalized wolf whistles, wolf whistle sequences, duet whistles, and kiss sequences and all kiss sound variations in a turn-taking fashion.

Context Differences in Unit Frequencies and Number of Units Used

In condition AL, Cosmo vocalized only slightly more frequently than when she was in the room with B. J. In contrast, the frequency with which Cosmo spoke when B. J. was out of the room was much higher than in both AL and IN. When B. J. had company (CO), Cosmo spoke with a much lower frequency than in all of the other conditions. Analysis revealed that unit frequencies were significantly different across condition, $X^2(3, N = 5{,}006) = 1911.47, p < .0001$. The number of individual units Cosmo used also differed across all four conditions. A chi-squared analysis showed that the size of Cosmo's "vocabulary" was, in fact, different across conditions, $X^2(3, N = 523) = 40.98, p < .0001$. The summary data are shown in Table 4.

Table 4 *Frequencies and Numbers of Units Used Across Social Conditions*

	SOCIAL CONDITION			
UNIT	Alone	In	Out	Company
Frequency *	1,336	1,324	2,261	85
Number *	145	187	171	20
*p < .0001.				

The 10 most frequently vocalized units and the frequencies with which they were used for each of the social conditions are shown in Table 5. For all the social conditions, the miscellaneous non-word (NWM) unit was ranked within the top 3 units. Similarly, wild songbird sounds (WBI) were also common to all four top 10 lists, but the frequencies varied. For conditions AL, IN, and OUT, the use of non-word sounds was predominant (comprising 90%,

80%, and 80% of each of the lists, respectively). Conversely, non-word vocalizations were only

20% of the top 10 list when B. J. was ignoring Cosmo in favor of speaking to company.

Table 5 *Ten Most Frequently Used Units Across Social Conditions*

ALONE		IN		OUT		COMPANY	
Freq.	Unit	Freq.	Unit	Freq.	Unit	Freq.	Unit
205	NWM	135	DUW	353	DUW	55	NWM
150	DS	122	NWM	307	WBI	4	wanna be a good bird
128	WBI	76	KS	179	NWM	3	wanna cuddle
69	DW	56	no	160	DS	2	cos don't bite okay
66	PH	37	WBI	102	i'm here	2	cosmo wanna be a good bird
35	OOO	34	OOO	81	MWH	2	don't bite okay
31	DUW	29	MWH	79	PH	2	no peanut
29	hello	22	wanna come here	54	DO	2	okay
28	RI	22	WF	49	DW	2	WBI
22	MWH	19	KS KS	46	i love you	1	come here
Sum = 763		Sum = 552		Sum = 1,410		Sum = 75	
"Freq." = Frequency.							

The duet whistle was ranked first in both the IN and OUT treatments. Interestingly,

though B. J. was in the room in the CO condition, the duet whistle did not appear in the top 10

list or in the full list of units used. Unlike in conditions AL and OUT, the use of non-word units

dog bark, dog whine, and phone beep were not in the top 10 lists for the two social conditions

when B. J. was in the room with Cosmo (IN and CO). Similarly, these two conditions were the

only ones with requests to approach ("wanna come here" and "come here," respectively) in their

top 10 lists of most frequently uttered units. Kiss sound units (KS and KS KS) were only used in

the IN condition's top 10 list. In the OUT condition "i'm here" ranked fifth, outranking four

more non-word sounds before the only other English unit, "i love you," in the tenth position.

While only two non-word units (NWM and WBI) appeared in the top 10 list in condition CO, those two units made up over three-fourths of the total frequency of units uttered in that condition. Considering frequency rather than actual units used, this indicates that the use of the non-word sounds in each condition's top 10 list was very high (96%, 86%, 90%, and 76%, respectively for AL, IN, OUT, and CO). Overall, Cosmo used non-word units approximately twice as frequently as English-only units in all four conditions except IN (see Table 6).

Table 6 *Unit Type Frequencies Across Social Conditions*

	SOCIAL CONDITION			
UNIT TYPE	Alone	In	Out	Company
English only	419	700	689	27
Non-word	907	586	1,535	58
English with non-word	10	38	37	0
Sum	1,336	1,324	2,261	85

The Spearman's *rho* correlation matrix ranking the full repertoire's 40 most frequently used units across the four conditions is shown in Table 7. A moderate correlation (+.65) existed between the rankings of the top 40 units in the full repertoire and how they ranked in the OUT condition. This implies that the units in these two top 40 lists ranked similarly. As highlighted in the table, correlations among all six comparisons of AL, IN, OUT, and CO were $-.07 \geq \rho \leq +.23$. These weak correlations suggest strong differences in how the full repertoire's top 40 units were ranked in each condition.

Table 7 *Intercorrelations of Rankings of 40 Most Frequently Used Units Across Social*

Conditions

SOCIAL CONDITION	Full	Alone	In	Out
Alone	.21	--	--	--
In	.11	-.03	--	--
Out	.65	.23	-.09	--
Company	-.07	.21	-.21	.09
Correlations calculated using Spearman's *rho*. "Full" = Full repertoire.				

Thematic Differences Across Condition

Concerning Cosmo's use of theme-related content, I addressed Cosmo's understanding of the use of themes in so far as she had learned that vocalizing with certain units was associated with a specific outcome. That is, I assumed that when Cosmo asked for a grape or to be let out of her cage, she was deliberately communicating with the appropriate units with the expectation of that unit's associated outcome.

I calculated the percentage of repertoire units used per theme in each condition. For example, if Cosmo used 14 units out of the 29 that were categorized as vocal interaction, the vocabulary richness for that condition was 48%. I also calculated the proportional frequency of units of a given theme out of the total frequency of all units that were coded in that condition. For example, if 300 utterances were associated with vocal interaction out of the total unit frequency of 1,324 in the IN condition, the percent of total frequency for that condition with respect to vocal interaction was 23%. Low ns due to low frequencies and counts precluded chi-square analyses from being performed for these tabulations.

Twenty-nine units were categorized as vocal interaction, including asking to kiss, whistle, or talk, as well as DUW, wolf whistle (WW), and all forms of KS. There were contextual differences in the relative frequencies with which Cosmo vocalized about this theme

(see Figure 1). When Cosmo was alone, 4% of her vocalizations were related to vocal interaction. While being ignored (i.e., the CO condition), the percent dropped to zero. Conversely, in conditions when B. J. was reciprocating interaction, the percentages of vocalizations about vocal interaction increased greatly, IN = 27% and OUT = 19%. Wide variation also existed across conditions in vocabulary richness (see Figure 2). Cosmo used twenty-seven out of the 29 selected units (93%) in condition IN. This dropped to 45% in OUT and 28% in AL. Cosmo's vocabulary was the richest and the content of her speech most frequently referenced vocal interaction during the IN condition.
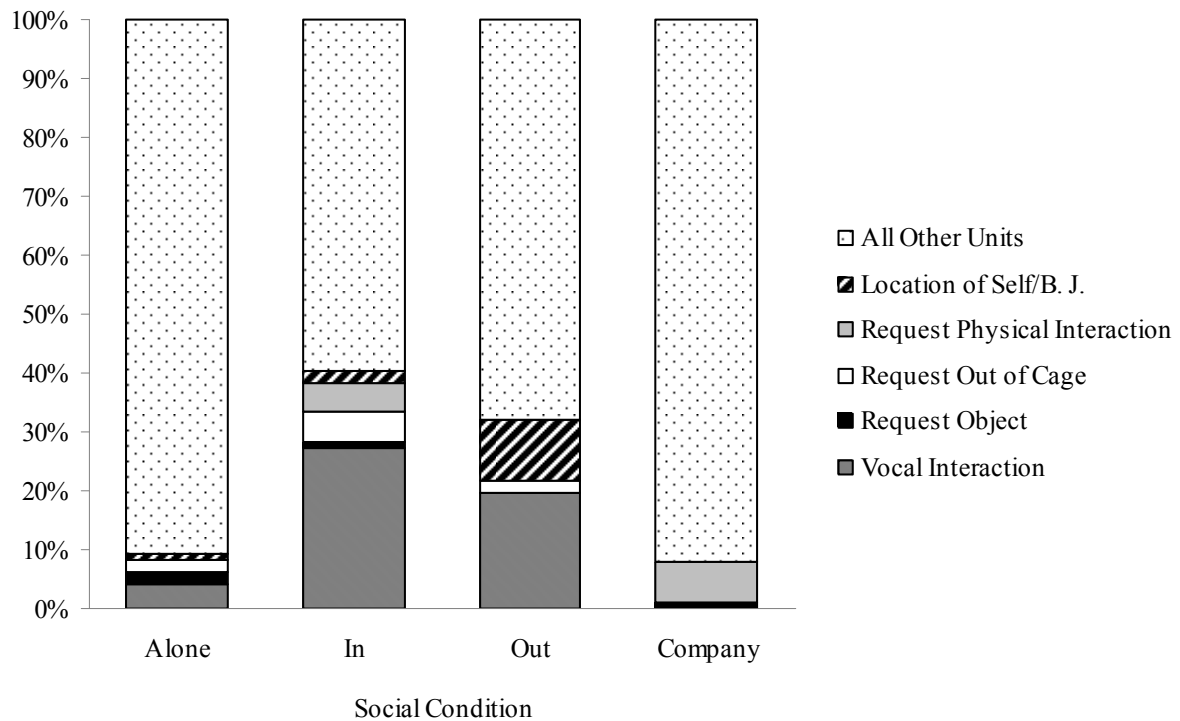
Figure 1. Frequency of Use of Themed Units Across Social Condition. Units that were not categorized within a theme comprise the "All Other Units" category. The theme of requesting to go to a different location was omitted from the figure due to < 1% scores for all conditions.

Ten units were requests for objects (e.g., grapes, peanuts, shower, and water). There was little variation across AL, IN, OUT, and CO (2%, 1%, < 1%, and 1%, respectively) in the relative

unit frequencies. Similar to vocal interaction, Cosmo's vocabulary was the richest in condition IN, where she used 7 out of the 10 request-related units. Half of the units were used in AL, 40% in OUT, and 10% in CO.
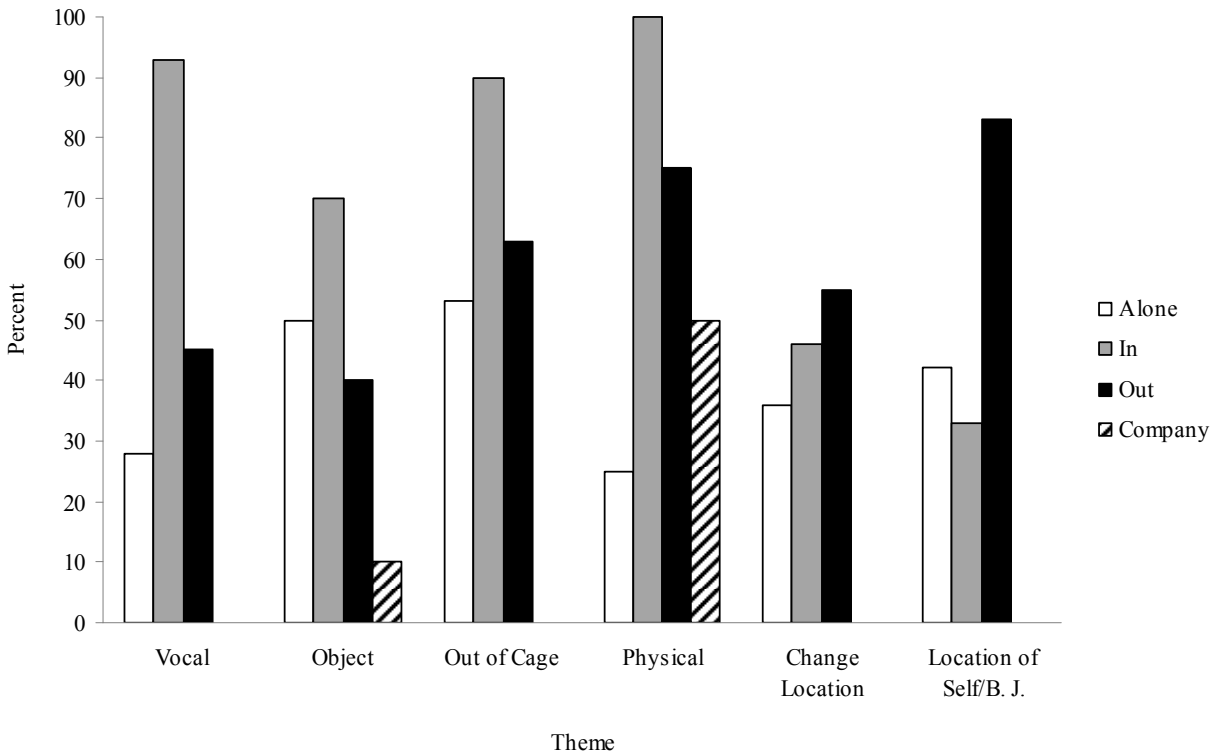
Figure 2. Vocabulary Richness of Themed Units Across Social Condition. Differences were measured in percentages of units used out of total number of units categorized within each of the six themes.

Nineteen units were categorized as regarding requests by Cosmo to be taken out of her cage, including "go up," "here step up," "wanna go up," and "be a good bird okay go up." The greatest frequency of this request occurred in the IN condition (5% of total vocalizations), followed by AL (2%), OUT (1%), and CO (0%). Cosmo's vocabulary richness about this theme was in accordance with the pattern of other themes, with the richest vocabulary being used when

B. J. was in the room with Cosmo (90%). Roughly half (53%) and 63% of the units were used in AL and OUT, respectively.

Eight units were categorized as requests for physical interaction, including "come here please," "Cosmo wanna cuddle," and "wanna come." Seven percent of the total unit frequency in CO was dedicated to this theme, 5% for IN, and < 1% for AL and OUT. Requests for physical interaction was the only theme in which CO's percent of total frequency was greater than in the other three social conditions. With respect to vocabulary richness, all eight of the units were used in the IN condition, 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, "Betty Jean room," the bedroom (probably synonymous with "Betty Jean room"), and going back in the cage. Even in the OUT condition, the frequency with which Cosmo requested to go to a new location was less than 1% across conditions. With the exception of CO, during which no requests to move to a different location were made, vocabulary richness was also comparable (AL = 36%, IN = 46%, and OUT = 55%). Unlike with previous themes, the OUT condition had the highest relative frequency (albeit by a fraction of a percent) and vocabulary richness.

Twelve units referred to Cosmo's spatial location 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. This percent was highest (10%) in the OUT condition. The richest vocabulary was also in the OUT condition (83%). These percentages were greatly reduced in the AL (42%), IN (33%), and CO (0%) conditions.

SECTION 4

DISCUSSION

This study demonstrated that features of one African Grey parrot's spontaneous vocal production changed drastically across different social situations. The results indicated that Cosmo attended to changes in the social aspects of her environment. B. J.'s presence did not appear to be a salient discriminative stimulus or cue for Cosmo to vocalize, as evidenced by the fact that she vocalized with equivalent overall frequencies when she was alone (AL condition) and when B. J. was in the room with her and reciprocated her vocalizations in the familiar way (IN condition). Moreover, the content of her vocalizations differed across contexts, as I summarize below, in ways that suggest that Cosmo often used speech and non-word sounds in ways that served social and facultative purposes.

B. J. was present in the room for two conditions, but Cosmo's vocalizations varied in these conditions as a function of B. J.'s responsiveness to her. In the company (CO) condition (where B. J. was present but ignored Cosmo), Cosmo used non-word units more than English-only units. Conversely, Cosmo used English-only units more frequently than non-word units when B. J. was in the room with her and reciprocated her vocalizations. Together, these data suggest that in the production of her vocalizations, Cosmo discriminates when B. J. is responsive, not just when she is present. Another indication that Cosmo tailors her speech to the social context is that she used non-word units such as dog sounds, miscellaneous one-note whistles, and telephone beeps proportionally more frequently in the AL condition. These sounds neither require nor promote reciprocated interaction, which may explain why they were used so

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frequently in this context. This supports the notion that her social partner's physical (visible) presence, by itself, is not the driving force behind Cosmo's use of speech. The partner's reciprocation also plays a strong role.

Cosmo used non-word units with an absolutely greater frequency than speech in the CO condition. Concurrently, she used a greater variety of speech units than non-word units (17 English-only units vs. 3 non-word 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 (as evidenced by multiple units being used only once or twice each), but a decrease in the repetition of any one speech unit. After multiple failed attempts to solicit interaction from B. J. using speech, Cosmo may have treated being ignored as being alone and vocalized with non-word units more frequently. Inspection of the distribution of speech units and non-word units may reveal a temporal pattern.

Overall, the frequency with which Cosmo vocalized during the CO condition, when B. J. did not reciprocate Cosmo's attempts to communicate, was surprisingly low. Given Cosmo's strongly bonded relationship with B. J., more vocal competition for B. J.'s attention on Cosmo's part was expected. According to B. J. (personal communication, 2008), she and her human company rarely ignore Cosmo. This novel circumstance may have suppressed Cosmo's vocal production in its entirety. Another explanation for the low frequency of vocalizations in the CO condition is that Cosmo's unfamiliarity with E. C. W. may have suppressed vocal behavior. The fact that her vocal production differed so dramatically in this context compared to the others in this study emphasizes how attentive Cosmo is to social context, and how social factors such as these influence her vocal production.

If social context matters to Cosmo (as I have demonstrated), then one might predict that Cosmo would hone her vocal production in varying social situations to only include contextually appropriate aspects of her repertoire. In this way, those units that are reinforced by responses from B. J. would be more likely to be repeated (e.g., "cosmo wanna kiss" during the IN condition), while those that do not would be less likely to be repeated (e.g., dog barks during the IN condition). Over time, Cosmo's vocabulary would be expected to change as a function of social context. However, this is not what I found. Many of the vocalizations Cosmo emitted were contextually neutral but still occurred with different frequencies across contexts. For example, B. J.'s telephone rings and the dogs vocalize independent of social context; but these vocalizations were only highly ranked during the two conditions when B. J. was not in the room (i.e., AL and out of the room [OUT] conditions). When B. J. was available to reciprocate, Cosmo produced these neutral units less frequently. Understanding Cosmo's differential use of contextually neutral units is difficult. A possible explanation is that she may be actively monitoring the social situation then deliberately tailoring her vocal production.

In addition to variations in frequency and vocabulary richness, the data suggest that Cosmo vocalizes using different theme-linked patterns depending upon the social context. I identified six themes in the corpus: vocal interaction, requests for objects, requests to get out of the cage, requests for physical interaction, request to move to a new location within the house, and units referencing Cosmo or B. J.'s spatial location. Cosmo produced higher proportions of units from the vocal interaction theme when B. J. reciprocated (i.e., IN and OUT conditions) than when she did not (AL and CO conditions). Further, Cosmo used vocalizations associated with vocal and physical interaction, requests, and references to her spatial location and B. J.'s location with a higher frequency during the IN and OUT conditions than during the AL and CO

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conditions. In AL and CO, Cosmo vocalized more often about non-theme content (for example, "that's squirrel," hawk imitations, and laser sounds) than theme content. This finding further implicates B. J.'s presence *and* willingness to reciprocate as major influences on Cosmo's vocal production.

There is a possibility that B. J. only uses certain themed units during certain contexts such that Cosmo associated 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, one might expect Cosmo's vocalizations to have little contextual overlap. However, Cosmo made contextually inappropriate utterances (such as asking for objects while alone). Her motives for making these vocalizations are unclear.

Interestingly, when vocal interaction was possible (IN and OUT), Cosmo appeared to prefer it over physical interaction. While wild parrots engage in extensive physical contact to promote social bonding (Spoon, 2006), Cosmo's preference for vocal interaction may be related to her confinement in a cage. In the IN and OUT conditions, the frequencies and number of units used that were associated with vocal interaction were more than triple those concerning physical interaction. However, Cosmo's vocalizations were more about physical interaction when B. J. ignored her. Cosmo may be making some distinction between which modality of interaction works and which does not. If Cosmo recognizes that her preferred vocal method of interaction is not possible, she may compensate by requesting more physical interaction. This would suggest that she first monitors who is in the room and what they are doing, then uses her vocal production in strategic ways to determine the best possible method of maintaining social contact with B. J.

My main thematic prediction was that Cosmo would be more likely to reference her own spatial location and that of B. J. during times of visual separation. The data supported this prediction, as evidenced by differences across condition in the relative utterance frequencies involving that theme. The contextual specificity with which Cosmo uses these units is a strong indication that she uses them deliberately. Moreover, she typically uttered the units with an amplified voice (similar to B. J.'s), and the vocalizations were persistent, repetitive, and frequently solicited vocal response from B. J. Discrete vocalizations used to solicit vocal interaction and maintain social contact is Bergman and Reinisch's (2006) functional definition of a contact call. Cosmo's vocal behavior supported the notion that she uses English words as an equivalent of contact calls.

Cosmo's use of speech in a conversational/social context is parallel in many ways to Kanzi's feats with keyboard-aided "speech" (Savage-Rumbaugh, 1986). Similar to Cosmo, Kanzi also can ask questions and express desires (Hillix & Rumbaugh, 2004); but mostly he answers questions, and he can express his own desires only within the scope of a pre-defined keyboard system. This severely restricts his ability to create novel utterances. Cosmo, on the other hand, can incorporate new vocalizations into her repertoire in a more flexible and open way that is only constrained by B. J.'s word use. While Kanzi has demonstrated the understanding of the syntax aspect of language (Hillix & Rumbaugh, 2004), careful evaluation of Cosmo's vocal production is necessary to determine the extent of her language-related abilities.

Excluding species-typical vocalizations such as barking, communicative acts by a non-human to a human are non-verbal and can take many forms including eye-gaze (e.g., Miklósi, Polgárdi, Topál, & Csányi, 2000), pointing gestures (e.g., Udell, Dorey, & Wynne, 2008; Xitco, Gory, & Kuczaj, 2001), and changes in outward behavior such as wagging the tail and defensive

postures (e.g., Vas, Topál, Gácsi, Miklósi, & Csányi, 2005). Communication between parrots and humans is a highly interesting exception to this rule. The variation in Cosmo's spontaneous vocal production, and specifically speech patterns, across social context demonstrates that African Grey parrots (and perhaps those passerines such as hill mynahs and some corvids that can replicate speech) are able to communicate vocally with humans differently than do all other non-human animals. This phenomenon deserves scientific attention for at least two reasons.

First, speech affords Cosmo the opportunity to communicate with B. J. about arbitrary content, such as commenting "Betty Jean have to leave" as B. J. gets ready for work in the morning. As Herman and Forestell (1985) remark, cases of non-human species communicating information that is not biologically relevant are rare. Cosmo can also communicate desires and preferences with greater precision than, for example, a dog, which cannot bark to communicate detailed information to its owner such as which kind of treat it wants (see also Pepperberg, 1999). Using speech, Cosmo has a vast repertoire of discrete vocal units. Precise and arbitrary referential speech is a hallmark of human language (Hillix & Rumbaugh, 2004). The extent to which Cosmo spontaneously uses her vocal units in a language-like manner deserves further investigation. Of course, human language includes many other elements than precise and arbitrary use of speech (Kako, 1999; Hauser, Chomsky, & Fitch, 2002; Hillix & Rumbaugh, 2004) and determining which or to what extent Cosmo's vocal production manifests these elements will be an interesting topic to pursue.

Second, the results of the current experiment change the way we think about the dynamic of social relationships between humans and non-humans. Until recently, the use of speech in inter-species communication was reserved for humans using vocal commands to solicit a response in another species. In this experiment, the roles were reversed: A non-human used

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speech in a goal-directed manner to solicit distinct responses from a human. Cosmo's ability to use speech has promoted the development of a reciprocated social relationship. She makes her desires known to B. J. through a medium of vocal exchange that both parties can use; this system heretofore has been solely the domain of humans.

Speech that is directed by a non-human to a human has a significant impact on how that human responds to the non-human. In Steven Spielberg's movie "E. T.: The Extra-Terrestrial," E. T.'s ability to communicate with Elliot using speech bridged a large gap that was crucial to Elliot developing positive emotions for and strong bonds to E. T. This "E. T. Phenomenon" is also found in human social relationships. For example, some Americans push to make English the "official language" in the United States (Fetzer, 2000). In this way, those non-native speakers who do learn to speak English are commended and accepted by native-speakers as being "American," while those who do not communicate with English are excluded and considered "Other." A non-human using speech opens a similar door of acceptance, slowly etching away at humans' long-time labeling of non-human species as "Other." In this way, Cosmo and others have helped make another barrier between humans and non-humans fall.

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APPENDICES

Appendix A: Table A1 Transcription Excerpt

2:54 ,we're gonna have company
2:55 /no no company today
2:58 ,no
2:59 /no
3:00 ,yes cosmo's a girl
3:02 /yes cosmo's a good girl
3:06 ,you have reached
3:12 /what
3:13 ,telephone for bird
3:15 /LA
3:19 /ID
3:19 ,ID
3:22 ,cosmo
3:24 /yes
3:26 ,cosmo wanna talk
3:28 /okay
3:29 /betty jean wanna talk
3:34 ,KS
3:35 /what's that
"," = Cosmo vocalizing; "/" = B. J. vocalizing

Appendix B: Cosmo's Full Repertoire

FREQUENCY	UNIT
561	NWM
519	DUW
474	WBI
316	DS
157	PH
133	MWH
122	DW
115	i'm here
108	KS
87	OOO
78	WF
75	no
70	DO
67	okay
66	i love you
55	hello
53	LS
50	RI
48	WW
47	here you are

43	goodbye
41	there you are
40	how are you
40	LA
36	CR
36	PHS
34	hi
33	what's that
29	hi tom
26	come here
26	wanna come here
25	wanna be a good bird
23	KS KS
22	DSS
21	cosmo wanna go up
21	cosmo wanna talk
21	DWS
21	HA
20	let go
19	here i are
19	what's bach
18	please
18	that's squirrel

18	wanna peanut
18	we're gonna go for a walk
17	AM
17	that's birdie
15	cosmo
15	what a bird
14	cosmo wanna be a good bird
14	here step up
14	that's WF
13	cosmo go up
13	fine thank you
13	look
13	telephone for bird
13	that's televi
13	what's bye
12	cosmo be a good bird
12	DUW i'm here
12	go up
12	hello cosmo
12	LSW
12	mary
12	okay go up
12	wanna cuddle

12	you have reached
11	cosmo wanna water
11	KS KS KS
11	wanna kiss
11	WBIS
11	we're gonna have company
11	where are you
10	betty jean wanna kiss
10	betty kiss
10	come here please
10	cosmo don't bite okay
10	cosmo wanna cuddle
10	doggies wanna go for a walk
10	DOS
10	KSS
10	that's bark
9	OU
9	that's tele
9	want kiss
9	wow
8	aww
8	fine thanks how are you
8	squirrel

8	telephone
8	what
8	what that
7	bark
7	come on
7	cosmo poop
7	don't bite
7	FR
7	hello kerri
7	kiss
7	mary has feathers
7	oh goodbye
7	okay goodbye
7	step up
7	you have reached betty jean
6	cos
6	KS KS KS KS
6	okay we're gonna go for a walk
6	that's beak
6	that's rain
6	wanna be a bird
6	wanna come
6	we're gonna have

5	bark WF
5	cosmo wanna kiss
5	don't bite okay
5	no peanut
5	step up here
5	that's
5	that's bark WF
5	wanna go up
5	wanna talk
5	we'll be back soon
5	what a good bird
5	what's bark
4	be back soon be back
4	betty jean have go in a car
4	cos don't bite okay
4	cosmo don't bite
4	cosmo has feathers MWH
4	cosmo has feet
4	cosmo wanna
4	cosmo wanna be a bird
4	cosmo wanna go for a walk
4	cosmo wanna go to bed
4	cosmo wanna shower

4	cosmo wanna whi DUW
4	cosmo's a birdie
4	fine
4	go up here
4	here step up here
4	hi tom how are you
4	let go please
4	mary has feathers MWH
4	NWMS
4	okay bye
4	OW
4	thank you
4	that's cosmo
4	that's doggie
4	wanna
4	wanna be a
4	wanna be a good
4	wanna whistle
4	we'll be back soon be back
4	we're gonna go
4	WWS
3	be a good bird okay go up
3	betty jean have

3	betty jean have to go in a car
3	betty jean have to leave
3	betty jean wanna
3	betty jean wanna kiss KS
3	come mary
3	cosmo go back cage
3	cosmo wanna come here
3	cosmo wanna go to kitchen
3	cosmo wanna go up here
3	cosmo's a bird
3	five four nine (Beginning of B. J.'s phone number)
3	(B. J. phone number digits)
3	good kiss
3	goodbye kerri
3	heygov
3	hi cosmo
3	hi tom LA
3	i love
3	i love you KS
3	kiss okay
3	let go LA
3	mary has
3	no more peanut

3	oh
3	okay cosmo
3	okay step up
3	peanut's in cage
3	tel for bird
3	televi
3	that's bye
3	that's doggie bark
3	that's wanna grape
3	that's water
3	wanna go back cage
3	wanna go to bed
3	wanna go up here
3	want kiss KS KS KS
3	want peanut
3	we'll be back
2	bad bird
2	betty go in a car
2	betty kiss KS
2	bye
2	cos don't bite
2	cosmo and B. J. wanna whistle
2	cosmo back in cage

2	cosmo be a go up
2	cosmo betty jean have go in a car
2	cosmo go up here
2	cosmo has feathers
2	cosmo LA
2	cosmo please
2	cosmo wanna go back cage
2	cosmo wanna peanut
2	cosmo wanna whistle
2	cosmo we're gonna go in a car
2	cosmo's a good good bird
2	doggie bark
2	good byelove you
2	HA HA
2	HAS
2	hello kaylee
2	here
2	here i
2	here you are here
2	how are thank you
2	i wanna kiss okay
2	KS KS KS KS KS KS
2	let's go to betty jean room

2	look cosmo
2	mary come on
2	no cos
2	oh thank you bye
2	okay come here
2	okay cos
2	okay dogs we're gonna go for a walk
2	okay goodbye NWM
2	okay let's go to kitchen
2	okay time for shower peanut
2	OOO what a bird
2	OU don't bite
2	peanut
2	peanut in cage
2	please step up
2	s
2	step up please
2	tele for betty jean
2	tele for bird
2	telephone for
2	thank
2	thanks bye PH
2	that's cosmo's a birdie

2	that's doggie has
2	that's kiss
2	that's paper
2	that's poop
2	that's wanna water
2	there you
2	time
2	wan go to bed
2	wanna go for a walk
2	wanna go to
2	wanna go to kitchen
2	wanna kiss KS KS
2	wanna kiss KSS
2	wanna peanut okay
2	wanna shower and peanut
2	wanna step up
2	wanna whi DUW
2	we're
2	we're gonna go for walk
2	we're gonna go in a car
2	what a good
2	what's
2	where cosmo

2	why thank
2	wow LA
2	yoohoo
2	you have reached cosmo
2	you LA

VOCAL INTERACTION   betty jean wanna kiss

betty jean wanna kiss KS

betty kiss

betty kiss KS

cosmo and betty jean

wanna whistle

cosmo wanna kiss

cosmo wanna talk

cosmo wanna whi DUW

cosmo wanna whistle

DUW

i wanna kiss okay

kiss

kiss okay

KS

KS KS

KS KS KS

KS KS KS KS

KS KS KS KS KS KS

KSS

wanna kiss

wanna kiss KS KS

wanna kiss KSS

wanna talk

wanna whi DUW

wanna whistle

want kiss

want kiss KS KS KS

WW

WWS

REQUESTS FOR OBJECT

cosmo wanna peanut

cosmo wanna shower

cosmo wanna water

okay time for shower

peanut

that's wanna grape

that's wanna water

wanna peanut

wanna peanut okay

wanna shower and peanut

want peanut

be a good bird okay go up

REQUESTS TO GET OUT

OF CAGE

cosmo be a go up

cosmo go up

cosmo go up here

cosmo wanna go up

cosmo wanna go up here

go up

go up here

here step up

here step up here

okay go up

okay step up

please step up

step up

step up here

step up please

wanna go up

wanna go up here

wanna step up

REQUESTS FOR PHYSICAL INTERACTION

come here

come here please

cosmo wanna come here

	cosmo wanna cuddle
	okay come here
	wanna come here
	wanna cuddle
REQUESTS FOR NEW LOCATION	cosmo back in cage
	cosmo go back cage
	cosmo wanna go back cage
	cosmo wanna go to bed
	cosmo wanna go to kitchen
	let's go to betty jean room
	okay let's go to kitchen
	wan go to bed
	wanna go back cage
	wanna go to bed
	wanna go to kitchen
REFERENCES TO LOCATION OF SELF/B. J.	DUW i'm here
	here
	here i
	here i are

here you are

here you are here

i'm here

there you

there you are

where are you

where cosmo

yoohoo