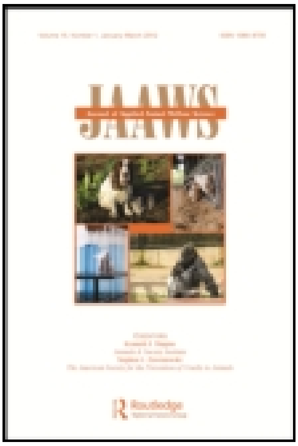

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Private nonhuman animal sanctuaries are often financially limited in their ability to implement traditional environmental enrichment strategies. One possible solution may be to provide socialized animals with human interaction sessions. However, the merit of human interaction as enrichment has received little empirical attention to date. The present study aimed to evaluate whether human interaction could be enriching for socialized, pair-housed wolves and wolf–dog crosses at a private sanctuary. Observations of each subject were conducted in a reversal design to measure species-typical affiliation, activity levels, and aberrant behaviors when caretakers were both present and absent. The results demonstrate significantly higher levels of conspecific-directed affiliation and activity levels and reduced aberrant behavior when human interaction was available. Social play also increased when caregivers were present, supporting the hypothesis that play among conspecifics may be maintained by positive changes in an animal's environment. The potential for human interaction to be established as a scientifically validated, cost-effective enrichment strategy is supported by these findings.

Keywords: *human interaction, canid, wolf–dog cross, evaluation, enrichment*

The benefits of environmental enrichment for mammals in the zoo and laboratory are widely documented in the empirical literature (Hoy, Murray, & Tribe, 2009; Tarou & Bashaw, 2007). However, enrichment strategies often cost time and resources to design, implement, and maintain. This indicates a need to establish cost-efficient enrichment methods that are effective in producing desired behavioral changes. In some cases, stimuli that are readily available in the captive environment may be more cost-effective in promoting overall welfare than are naturalistic forms of enrichment (Wells, 2009).

Given that human caretakers provide nonhuman animals in captivity with basic survival needs, the potential for human–animal interactions to be enriching has been proposed for captive animals who have positive relationships with humans (Claxton, 2011). The majority of research on human–animal interactions in this context has focused on the use of positive reinforcement

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training (PRT) to promote desirable behaviors while simultaneously providing an opportunity for positive interactions between animals and their caregivers (Baker, Bloomsmith, Neu, Griffis, & Maloney, 2010; Claxton, 2011; Laule, Bloomsmith, & Schapiro, 2003). Although PRT is clearly relevant to developing target behaviors that make aversive husbandry techniques obsolete (Laule et al., 2003) and improve behavioral welfare (Bassett, Buchanan-Smith, McKinley, & Smith, 2003; Schapiro, Bloomsmith, & Laule, 2003), PRT is often confounded with food reinforcement, thus obscuring the effects of human interaction alone on captive animals.

The merit of free-contact interactions between captive animals and their human caretakers as environmental enrichment has only recently been subjected to scientific analysis. Most studies have examined nonhuman primates. For example, positive interactions with caretakers reduced stereotypic behavior in solitary and socially housed chimpanzees in the laboratory (Baker, 2004; Bloomsmith, Laule, Alford, & Thurston, 1994; Waitt, Buchanan-Smith, & Morris, 2002), and macaques and socially housed common marmosets exhibited increased grooming (Baker, Bloomsmith, Griffis, & Gierhart, 2003; Manciocco, Chiarotti, & Vitale, 2009; Waitt et al., 2002). In addition, human interaction has been found to produce positive behavioral changes for shelter dogs, including improved sociability (Bergamasco et al., 2010; Normando, Corain, Salvadoretti, Meers, & Valsecchi, 2009) and lower cortisol levels (Coppola, Grandin, & Enns, 2006); however, the male rhesus macaques exhibited higher rates of abnormal behaviors during human interaction sessions (Maloney et al., 2007).

The literature concerning the impacts of human interaction alone for captive animals is thus limited by restricted species generality and inconsistencies regarding the efficacy and implementation of such interactions even within related species.

Studies on human–animal interactions as enrichment are also limited by the lack of systematic evaluation of individual data. Because behavioral welfare is a property of individual animals, group designs and analysis of aggregate data only may not accurately reflect enrichment efficacy. In addition, none of the prior studies were designed to permit direct analysis of cumulative behavioral change resulting from alternating conditions of caregiver presence and absence. Important changes in behaviors of interest may occur not only when enrichment is available, but following its removal as well. Finally, the reliability of enrichment effectiveness may be demonstrated by replications of the experimental conditions, which were generally not conducted in these studies.

An ideal population for the evaluation of human interaction as putative enrichment is exotic animals in private sanctuaries. These animals often have a unique developmental and learning history of extended contact with humans. In addition, many such facilities are nonprofit organizations that are run entirely on caretaker assistance and private donations, making traditional environmental enrichment strategies both physically and financially difficult to implement. In this case, human interaction may serve as a financially feasible and readily accessible strategy to promote the welfare of captive animals who have been hand-reared by humans in these unique settings.

A large proportion of the animals in such facilities are wolves and wolf–dog crosses. A wolf–dog cross is a cross between a wolf (*Canis lupus*) and a dog (*Canis familiaris*) or between animals where one or both parents have recent wolf genes (Cusdin & Greenwood, 2000). At present, there are estimated to be anywhere from 300,000 to 1.5 million wolf–dog crosses in captivity in the United States (Busch, 2007). In many cases, wolves and wolf–dog crosses are relinquished voluntarily by their owners or are confiscated by wildlife officials from situations in which the animals were illegally obtained and/or possessed or improperly cared for. At present, however, there have not been any peer-reviewed publication reports on the behavioral management of captive wolf–dog crosses despite their growing popularity as companion animals and residents at captive wildlife facilities. Because wolf–dogs are exotics, legal ownership is prohibited in many states, and they are therefore not adopted out into the community. Thus, effective environmental enrichment is central to the welfare of this population.

The objective of this study was to assess if human interaction could serve as enrichment for pair-housed wolves and wolf–dog crosses at a sanctuary. We evaluated the ability of contact with familiar caregivers to increase the occurrence of species-typical affiliative behavior, increase activity levels, and decrease the occurrence of any aberrant behaviors that were observed when human interaction was not provided.

METHOD

Subjects

The subjects were two socialized wolves and six wolf–dog crosses (Table 1). Wolf–dog crosses were reportedly of varying wolf content, which was determined by noting physical similarities to a wolf phenotype (Cusdin & Greenwood, 2000). All wolf–dog crosses in this study were identified as such by state officials prior to the onset of the study (J. S. Knight, personal communication, May 20, 2011) and were categorized either as high-content wolf–dogs (80%–99% wolf phenotype), midcontent wolf–dogs (40%–79% wolf phenotype), or low-content wolf–dogs (5%–39% wolf phenotype; J. Haynes, Florida Lupine Association, personal communication, June 23, 2011).

Sampson and Spirit were sibling hand-reared wolves purchased from a private breeder in Texas. Both had been housed together at other facilities. All remaining pairs had not been previously housed together before arriving at the sanctuary. Sabbath and Ava were siblings and reportedly low-content wolf–dog crosses. Sabbath and Ava previously had separate caretakers;

TABLE 1
Demographics of Subjects at Big Oak Wolf Sanctuary

Pair/Names	*Gender*	*Age (years)*	*Breed*	*Sibling Pair*
Pair 1				Yes
Sampson	Male	5	Gray wolf	
Spirit	Female	5	Gray wolf	
Pair 2				Yes
Sabbath	Male	3	Wolf–dog	
Ava	Female	3	Wolf–dog	
Pair 3				No
Peace	Male	3	Wolf–dog	
Lea	Female	4	Wolf–dog	
Pair 4				No
Peter	Male	4	Wolf–dog	
Sara	Female	5	Wolf–dog	

the reasons for their relinquishment are unknown. Peace and Lea were reportedly high-content and low-content wolf–dog crosses, respectively; they were purchased from breeders by private caretakers. Peter and Sara were reportedly low-content wolf–dog crosses. Sara was purchased from a breeder at 12 weeks old and was brought to the sanctuary 3 weeks later. Peter was adopted from an animal shelter but was subsequently surrendered when authorities informed the caretakers that he was a wolf–dog cross.

All subjects were adults who had been housed at the sanctuary for a minimum of 2 years at the time of the study. Each subject was housed with a conspecific of the opposite sex (e.g., wolf–dog crosses were paired with other wolf–dog crosses and wolves were paired with wolves). All pairs were housed together for a minimum of 1 continuous year prior to the study. All subjects remained in their original pairs throughout the study. One pair of wolf–dogs—Peter and Sara—was relocated to a different enclosure between the first and second replications for management reasons. Subjects were chosen for this study based on how socialized they were to familiar people and on their ability to interact safely with a single person in the enclosure. All subjects were spayed or neutered prior to the onset of the study.

Materials

All subjects were housed at Big Oak Wolf Sanctuary (Green Cove Springs, FL) at the time of this study. The sanctuary is a privately owned, nonprofit organization that provides long-term residence and care to neglected and confiscated wolves and wolf–dog crosses. The facility was not open to the general public, but all animals were accustomed to interaction sessions several times per week with sanctuary caretakers. All subjects were housed in similar enclosures (ranging from 2,286 m^2 to 3,048 m^2) surrounded by chain-link fencing (approximately 3.1 m in height) around the perimeter. All enclosures included a 2.6-kL pool, a wooden platform (3.1 m in height and 3.7 m × 3.7 m) above the pool, and an underground den (approximately 4.9 m × 2.4 m).

All observations were collected between the hours of 5 p.m. and 7 p.m. from June through September 2011. Observations were never conducted within 30 min of a feeding or within 6 hr of caretaker interactions. Two female caretakers participated in each separate intervention condition per replication. The order of the caretakers within each session was held constant across all replications for all subjects. Caretakers had at least 3 months of providing human interaction with all subjects, and they were knowledgeable about the temperament of the subjects and were trained to interact safely with each animal. In accordance with the sanctuary's protocols, caretakers were instructed to never restrain subjects, make quick or sudden movements, pet quickly or forcefully, stare at the subjects directly in the eyes for prolonged periods of time, or give reprimands. All observations were video-recorded using a high-definition camera (Kodak Zi6 HD Pocket Video Camera, Eastman Kodak Company, Rochester, NY) that was positioned several meters from the front of the enclosure or on an adjacent platform overlooking the subjects' enclosures.

Procedure

An A-B-A-B-A reversal design was used to evaluate the effects of unstructured human interaction for pair-housed wolves and wolf–dog crosses. A reversal design entails repeatedly alternating no-treatment (baseline, A) and treatment (intervention, B) conditions within each period of observation to determine the efficacy of a particular intervention (Johnston & Pennypacker, 2008; Shadish, Cook, & Campbell, 2002). Each pair was observed for 35 min, which consisted of an initial 5-min baseline condition, followed by a 10-min treatment condition, a subsequent 5-min return-to-baseline condition, a second 10-min treatment condition, and a final 5-min baseline condition. The timing of each condition was selected to reflect the alternation and duration of human interaction sessions as they were typically employed at the sanctuary. Three replications of observations were conducted for each pair, with 2 weeks between each replication. Replications were conducted to assess the reliability of the data obtained for each pair (Johnston & Pennypacker, 2008).

Baseline conditions were measured in the absence of a person in the enclosure, but still in the presence of the conspecific with which the subjects were always paired. During intervention conditions, a familiar female caretaker (with at least 3 months of experience of providing food and social interaction to subjects) was instructed—either by the lead author or signaled by a preset timer—to enter the enclosure and interact with the subjects if they approached her, regardless of what the subjects were doing at the time of caretaker entry. Social interactions included providing both tactile petting and verbal praise to subjects if the subjects engaged with or were in close proximity to her (within an arm's length). Thus, most of the interactions provided were not contingent on conspecific social behavior or activity. Caretakers were specifically instructed not to encourage play with the subjects (e.g., by providing toys, grabbing onto any part of the animal's body) or solicit interactions (e.g., by following subjects around the enclosure, calling subjects' names) if the subjects did not engage with them during the intervention condition.

If interactions between conspecifics occurred during intervention conditions, caretakers were permitted to monitor the interaction but were instructed to avoid responding in any way that could potentially interfere with the interaction (e.g., calling out subjects' names, moving from a stationary position, emitting an audible nonverbal cue). Tangible items (e.g., edible treats, novel items, toys, training materials) were never present during baseline or intervention conditions. All observations were subsequently viewed from videotape as a treatment integrity procedure.

Behaviors of interest are listed in the ethogram (Table 2). All durations of conspecific, human, and other affiliation were recorded as measures of species-typical behaviors. All durations of aggression, inactivity, scent rolling or scent rubbing, pacing, aberrant behavior (e.g., cage chewing), and vocalizations were also recorded. Other behaviors were defined as any other behavior not explicitly defined in the ethogram and thus were mutually exclusive from all other behaviors in the ethogram. The requirement for recording a bout of behavior was that the behavior had to be observed for at least 3 s; similarly, the end of a bout required observation of at least 3 s in the absence of that behavior (with the exception of the not-visible condition).

Proximity measures were scored as in contact, proximate (within an arm's length from the caretaker or within a body's length from the conspecific), or distant (greater than an arm's length from caretaker or a body's length from the conspecific) and were recorded instantaneously every 10 s in each condition. The percentage of time spent inactive for each condition was also calculated for each subject. "Not visible" was coded if the subject could not be seen for 30 s or more and the behaviors coded immediately before and after this bout were not identical.

TABLE 2
Ethogram of Species-Typical and Abnormal Behaviors for Wolves and Wolf–Dog Crosses

Behavior	*Definition*
Conspecific affiliation	Tail wagging, licking (usually face, but may be any part of body), or submission (may include crouching and licking while greeting, rolling on back or side and exposing underbelly) while oriented toward conspecific.
Human affiliation	Tail wagging, licking (usually face, but may be any part of body), or submission (may include crouching and licking while greeting, rolling on back or side and exposing underbelly) and sniffing while oriented toward volunteer.
Other affiliation	Tail wagging, ears back, but not oriented toward any identifiable target.
Aggression	Any aggressive response directed toward another animal or person; includes all noncontact aggression (e.g., growling, snarling, raised hackles, teeth baring) and contact aggression (e.g., inhibited biting, injurious biting, shoving, knocking over).
Inactive	Subject's body is stationary/immobile but not standing (e.g., sleeping, resting); head may be erect or moving (e.g., looking around, panting).
Not visible	Any occurrence in which you cannot clearly see more than 50% of the animal's body and/or such that you cannot identify the subject or his or her behavior with certainty. Recording "not visible" constitutes a 30-s period in which the subject meets these criteria and in which the previously recorded and subsequently recorded behaviors are not identical.
Other	Subject is alert (eyes open). Record "other" any time the subject is moving and not stationary (except while standing; e.g., walking, grooming, digging).
Pacing	Subject repeatedly (more than 3 times, with no more than a 3-s pause at any time) walks in a fixed route in the enclosure (adapted from Hubrecht, Serpell, & Poole, 1992).
Scent rolling[a]	Subject presses and subsequently rubs his or her body and/or head onto volunteer (can also be onto another object); may include rolling on back from side to side.
Social play	Any nonaggressive interaction between two pair-housed animals occurring for at least 5 s that also includes reciprocal wrestling and chasing, with both animals exhibiting relaxed body postures simultaneously.
Aberrant	May include cage chewing, tail chasing, and concentrated self-biting and/or self-licking that is compulsive (lasts for more than 15 s) and/or results in hair removal, irritated skin, bleeding, etc.

Note. Definitions of all occurrence behaviors were recorded in durations (seconds). A minimum of 3 s constituted the onset and offset of each behavior.
[a]Behaviors were recorded at such low frequencies that statistical analyses could not be conducted.

All observations were coded from digital video on the computer for interobserver reliability (minimum of 90% agreement in all conditions). All behavior measures were recorded using Microsoft Excel Version 11.5.0. Activity levels were calculated by subtracting the duration of time in which each subject was observed as inactive from the total duration of each condition. Durations of activity, affiliative behavior, pacing, and aberrant behaviors were subsequently calculated across all conditions and replications and were converted to proportions for each condition to account for the differences in the lengths of baseline and intervention conditions.

Human affiliation and social play were recorded as durations. The duration of social play observed in each condition was recorded, and then it was divided by the total time elapsed in each condition and multiplied by 100% to obtain the percentage of time spent in each condition in which social play was observed. Human proximity and conspecific proximity measures were calculated as percentages per condition across all conditions and replications.

Proportions of behavior observed for each condition and subject were not normally distributed and were consequently square root-transformed and arcsine-transformed to achieve normality (Winer, 1971). This transformation resulted in normally distributed data.

As all subjects were pair-housed, each pair (not subject) was considered as an individual case for the statistical analyses of transformed data for all measures of social behavior: conspecific proximity, total affiliation, and conspecific affiliation. Each subject was considered an independent sample for activity-level data.

For each replication, a *t* test was used to compare transformed proportions of time in proximity to the human and conspecific between intervention and baseline conditions to determine if there was an effect of caregiver. In addition, a *t* test was used to compare transformed proportions of proximity scans (in which subjects were not distant to conspecifics) between intervention and baseline conditions. Pairwise *t* tests were used to compare human proximity scans between intervention conditions to determine if subjects spent significantly more time near one caretaker. A repeated-measures analysis of variance was subsequently used to compare square-root arcsine-transformed proportions of behavior observed for each condition within subjects. Planned unpaired *t* tests were also conducted to generate pairwise comparisons between conditions for each replication. All statistical analyses were conducted using Microsoft Excel Version 11.5.0 or the Statistical Package for the Social Sciences Version 18 (SPSS Inc., Chicago, IL).

RESULTS

Species-Typical Affiliative Behavior

Transformed proportions of conspecific-directed affiliation were significantly higher in intervention conditions relative to baseline conditions for Replication 2 ($F = 4.97$, $p < .02$) and Replication 3 ($F = 74.0$, $p < .001$, where $df = 4, 12$ for all F tests); this effect was not observed for Replication 1 ($F = 2.89$, $p = .07$). The percentages of conspecific affiliation observed for each pair are presented in Figure 1. Results of planned pairwise comparisons between conditions in Replications 2 and 3 are presented in Table 3. Transformed proportions of total

TABLE 3
The *t* Values for Pairwise Comparisons of Proportions of Conspecific Affiliation Between Conditions Across Replications 2 and 3 ($df = 3$)

	Baseline 1	*Baseline 2*	*Baseline 3*
Replication 2			
Intervention 1	−2.51	2.51	2.69
Intervention 2	−3.29*	−3.86*	2.13
Replication 3			
Intervention 1*	18.0***	30.5***	9.51*
Intervention 2*	−3.86*	−2.22	3.84*

*$p < .05$. ***$p < .001$.

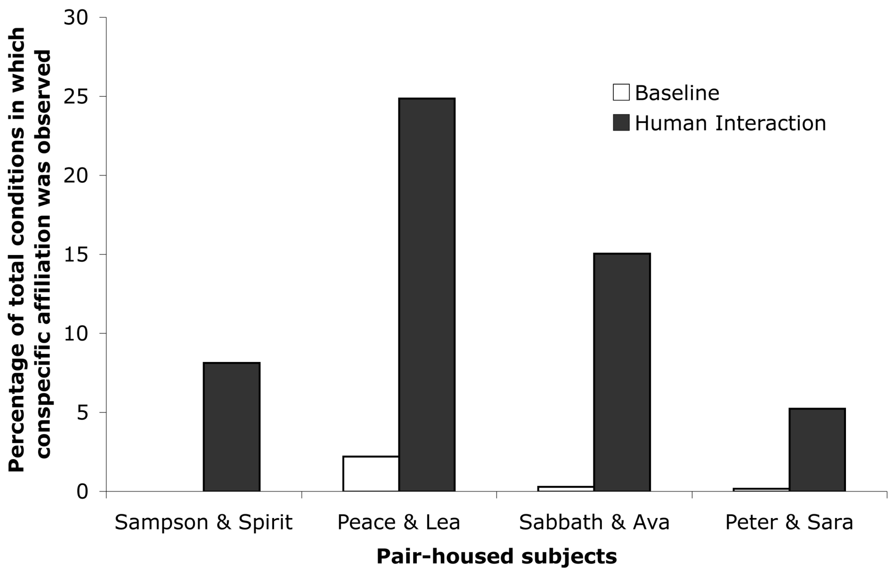

FIGURE 1 Relative levels of conspecific affiliation for all pairs of subjects in baseline and human interaction conditions. Series represent the percentage of baseline and human–animal interaction conditions across replications in which subjects were recorded as engaging in conspecific affiliation.

affiliation were significantly higher in intervention conditions relative to baseline conditions for all replications ($p < .001$): Replication 1, $F = 24.8$; Replication 2, $F = 30.8$; and Replication 3, $F = 92.2$ (where $df = 4, 12$ for all F tests).

Planned pairwise comparisons revealed significant differences between all intervention and baseline conditions within all replications (see Table 4). There were no significant differences

TABLE 4
The *t* Values for Pairwise Comparisons of Proportions of Total Affiliation Between Conditions Across Replications ($df = 3$)

	Baseline 1	*Baseline 2*	*Baseline 3*
Replication 1***			
Intervention 1	−10.8**	−8.34**	6.30**
Intervention 2	−4.04*	−7.57**	7.46**
Replication 2***			
Intervention 1	−10.8**	7.50**	4.80*
Intervention 2	−11.6**	−10.7**	3.91*
Replication 3***			
Intervention 1	−10.4**	12.2**	10.4**
Intervention 2	−21.7***	−12.0**	21.7***

*$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 5
Percentage of Time Social Play Was Observed in Human Interaction Conditions for Wolves and Wolf–Dog Crosses

	Replication 1		*Replication 2*		*Replication 3*	
Pair	*H1*	*H2*	*H1*	*H2*	*H1*	*H2*
Sampson & Spirit	0%	0%	0%	3.7%	6.0%	0%
Peace & Lea	4.7%	0%	16.7%	9.3%	3.7%	4.2%
Sabbath & Ava	0%	21.5%	33%	0%	10.5%	0%
Peter & Sara	7.0%	0%	0%	4.3%	4.0%	0%

Note. First and second human interaction conditions are labeled "H1 (Human interaction condition 1)" and "H2 (Human interaction condition 2)" per pair, respectively, across replications.

in total or conspecific affiliation between any two baseline conditions across replications ($t = 1.8$, $df = 3$, $p = .11$). In Replication 1 and Replication 2, no significant differences between intervention conditions were detected in total or conspecific affiliation. In Replication 3, a significant difference in conspecific affiliation ($t = 10.7$, $df = 3$, $p < .01$) was found between the Intervention 1 and Intervention 2 conditions.

Durations and percentages of social play observed for each intervention condition for all pairs are reported in Table 5. Social play was never observed in baseline conditions.

Proximity Measures

The transformed proportions of proximity scans in which the subject was observed in contact, proximate to, or distant from both the other conspecific and human were calculated for all conditions. The proximity to the conspecific is shown in Figure 2. No significant difference was found in the proportion of time the conspecifics spent near one another when baseline and intervention conditions were compared in Replication 2 and Replication 3. A significant

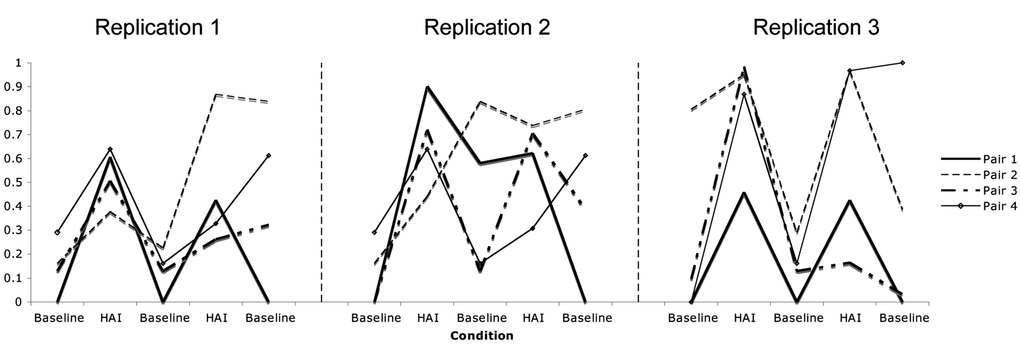

FIGURE 2 Proportions of scans per condition in which pair-housed conspecifics were observed in close proximity to one another during baseline and human–animal interactions (HAI) across replications.

difference was found in Replication 1 ($F = 3.8$; $df = 4, 12$; $p < .05$); however, pairwise comparisons did not reveal any significant differences in any comparison of baseline and intervention conditions. For three of the four pairs, higher proportions of time per condition that conspecifics spent in close proximity to one another were observed in baseline conditions following human interaction relative to the initial baseline (see Figure 2).

On average, subjects spent 66.03% of intervention conditions in close proximity (in contact or within an arm's length) of the caretaker. Peter spent the most time near the caretaker during interaction sessions (90.44% on average) and Spirit spent the least amount of time near the caretaker (53.55% on average). In addition, subjects spent significantly more time in close proximity to the first handler within each replication than to the second handler, as there were significant differences in the proportions of time subjects spent near the caretaker between intervention conditions for Replication 2 ($t = 3.56$, $df = 7$, $p < .001$) and Replication 3 ($t = 2.4$, $df = 7$, $p < .05$); this effect was not observed for Replication 1.

Interactions were observed between human and conspecific proximity data for all individual subjects during intervention conditions. Mean percentages of scans in which subjects were observed near (defined as either in contact or proximate to) both the caretaker and conspecific during intervention conditions were as follows: 67.9% for Ava (range = 21.4%–94.8%), 76.4% for Sabbath (range = 50.9%–100%), 82.3% for Peace (range = 37.2%–100%), 74.0% for Lea (range = 32.6%–88.6%), 62.4% for Sampson (range = 42.3%–75.0%), 73.2% for Spirit (range = 19.2%–89.3%), 91.7% for Peter (range = 85%–100%), and 77.0% for Sara (range = 55.0%–94.2%).

Activity Levels

Figure 3 shows the mean percentage of time each subject was observed being active during baseline and human interaction conditions. Activity levels were significantly lower in the

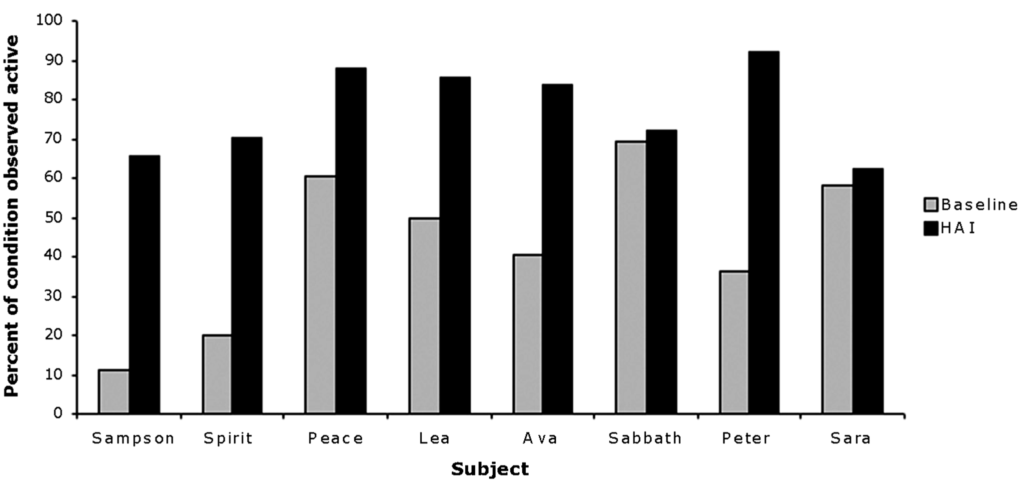

FIGURE 3 Activity levels for all subjects. Series represent the percentage of baseline and human–animal interaction (HAI) conditions across replications in which subjects were recorded as active.

TABLE 6
The *t* Values for Pairwise Comparisons of Proportions of Activity Between Conditions Across Replications ($df = 7$)

	Baseline 1	*Baseline 2*	*Baseline 3*
Replication 2***			
Intervention 1	−3.25*	2.03	2.64
Intervention 2	−3.62	3.2**	2.95
Replication 3***			
Intervention 1	−8.74***	2.91	10.4**
Intervention 2	−8.40**	−1.34	4.2**

*$p < .05$. **$p < .01$. ***$p < .001$.

baseline conditions relative to the intervention conditions in both Replication 2 ($F = 7.45$, $df = 4, 28$, $p < .001$) and Replication 3 ($F = 13.5$, $df = 4, 28$, $p < .001$); this effect was not observed in Replication 1. Planned pairwise comparisons in Replications 2 and 3 are presented in Table 6. In Replication 1, three subjects exhibited much higher rates of activity in the intervention conditions relative to baseline conditions, while the remaining five subjects did not.

Durations of pacing observed per condition were also analyzed by visual inspection for all subjects who exhibited this behavior; the low number of subjects who exhibited pacing in this study did not permit statistical analysis. Two subjects exhibited higher rates of pacing during baseline conditions relative to human interaction conditions in some replications (see Figure 4). Cage chewing was observed in only one subject, Ava, during baseline conditions

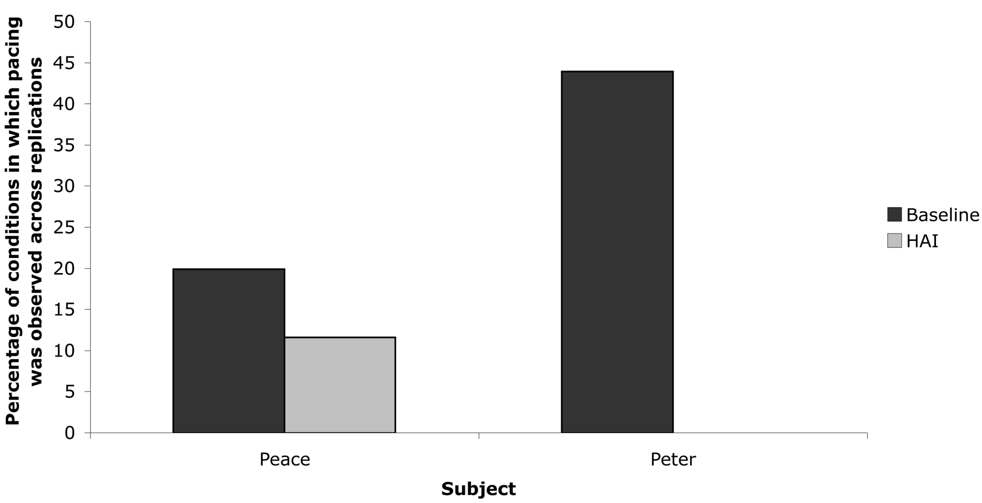

FIGURE 4 Levels of pacing for subjects ($n = 2$) who exhibited the behavior. Series represent the mean percentage of baseline and human–animal interaction conditions (HAI) across replications in which subjects were observed pacing. Peter was never observed pacing in any HAI conditions.

following human interaction conditions for Replication 2. Because this behavior was only observed in two conditions for a single subject, statistical analysis was not possible.

DISCUSSION

Enrichment is defined such that we cannot know if a strategy is "enriching" until we observe its effects on specific behaviors (Hoy et al., 2009); from these effects, assessments can be made with respect to an animal's well being. The data presented here suggest that human interaction alone has the potential to be enriching for pair-housed wolves and wolf–dog crosses who are socialized to humans. This is demonstrated by higher rates of species-typical affiliation toward humans and conspecifics, higher activity levels for the majority of subjects, low levels of aggression, and decreased pacing for all subjects who exhibited this behavior in baseline conditions.

The increases observed in social interaction among conspecifics are consistent with Baker's (2004) findings regarding the impact of human interaction on socially housed chimpanzees, and they fit the goal of enrichment to increase opportunities for species-typical behaviors (Shepherdson, 1998). In addition, the high durations subjects spent engaging in human-directed affiliation and in close proximity to the caretaker during human interaction conditions not only suggest that human interaction increased subjects' behavioral choices relative to baselines, but also demonstrate that the subjects exhibited a great deal of behavioral flexibility to life in captivity. This is important considering that animal welfare may be defined as the state of an animal in his or her attempts to cope with the environment (Broom, 1986).

Conspecifics also spent a significantly greater proportion of time in close proximity to one another when a caretaker was present in the enclosure in two thirds of replications. Thus, free-contact interactions with familiar human caregivers appear to be an effective strategy for increasing species-typical social affiliation and enhancing conspecific interactions in socialized, pair-housed wolves and wolf–dog crosses.

Significant increases in activity levels were observed during intervention conditions in Replication 2 and Replication 3; however, no such effect was found in Replication 1. Upon closer examination of the data, it appears that average activity levels were confounded by high rates of stereotypic behavior for two subjects in Replication 1. Peter and Peace exhibited a high frequency of pacing behavior in the initial baseline conditions, followed by a dramatic elimination of pacing in the first intervention condition. This led to a decline in the average rates of activity across all subjects in Replication 1, though it is possible that this may have been influenced by Peter and Sara's relocation to another enclosure before Replication 2. In addition, an additional subject, Ava, exhibited cage chewing during both return-to-baseline conditions in Replication 2. These findings suggest that increases in activity level alone do not necessarily reflect an improvement in welfare. Future studies should ensure that the quantity and the nature of activity exhibited are assessed.

Several limitations of the current study should be noted. First, human interaction may be relatively time-consuming compared with other enrichment strategies. In addition, the dramatic increases observed in affiliative behaviors during human interaction appear to be temporary. Most subjects, with the exception of Peace and Lea, exhibited affiliative responses only during the interventions. This suggests that these high rates of increased social interaction require the continued attention of a familiar caretaker to be maintained. This finding is of interest both for theoretical questions about the proximate functions of social affiliative behavior in captive animals, as well as practical questions in applied settings.

Many facilities that house captive animals seek ways to continuously promote positive, naturalistic social interactions among their animals, including during times when staff members are not available to interact with the animals. Therefore, different schedules of social reinforcement (Tarou & Bashaw, 2007) should be explored for their ability to promote the maintenance of positive intraspecific behavior to maximize welfare in captive canid populations.

Subjects' proximities to their cage mates (during both baseline conditions and human interaction conditions) and to the caretaker (during human interaction conditions only) are measures of enrichment efficacy that should be interpreted with caution in this study. First, proximity measures were coded from video and therefore may have been inexact. In addition, conspecific proximity and proximity to the caretaker were not independent of one another. Conspecific proximity may have been enhanced simply because both animals were engaging or attempting to engage with the caretaker, and not necessarily with one another. However, there was an increase in the proportion of time that conspecifics spent near one another from the initial baseline to the first intervention condition, but not between subsequent baseline conditions and interventions. This is likely because pair-housed animals simply remained in close proximity to one another after human interaction was no longer available (Figure 3). The effects of human interaction on proximities therefore appeared to be maintained through subsequent conditions.

All subjects spent, on average, more than half of each human interaction condition near the caretaker. In Replications 2 and 3, there were significant differences in the proportion of time spent in close proximity to the caretaker between the first and second intervention conditions. There are several possible explanations for this. One possibility is that all subjects may have a preference for one caretaker over another. The caretaker that was present in all first interaction sessions was the co-owner of the facility and thus was more familiar to the subjects than the second caretaker, who had been with the sanctuary for 3 months.

A second possibility is that the subjects were somewhat satiated by human interaction in the 10-min session durations. It would thus be worthwhile to examine the effect of a longer intertrial interval and return-to-baseline condition if there are limited caretakers or there is limited time to allocate to human interaction sessions. A third explanation for the finding is that it is simply an order effect, because the co-owner was presented first each time and the animals had habituated to the testing when the second caretaker entered. Future studies on human interaction as enrichment should take these possibilities into account.

Different motivating factors—including proximity to feedings and length of time between caregiver interactions—might have also influenced the efficacy of human interactions and should be explored further. In addition, the relationships of the pairs of animals used in this study also might have influenced subjects' likelihood of engaging in conspecific affiliation. For example, sibling pairs may be more likely than nonsibling pairs to engage in affiliative behaviors with one another. Given that many private sanctuaries need to create artificial pairs, this would be an interesting area for future research.

It is worth noting that the increases observed in conspecific affiliation during human interaction conditions included multiple occurrences of social play across pairs. Furthermore, increases in play were associated with concurrent decreases in pacing for subjects who exhibited this behavior in baseline conditions. This is consistent with observational findings that social play in captive wolves occurs when stress is low (Cordoni, 2009) and that play behavior may be a potential indicator of animal welfare in suitable environments (Held & Spinka, 2010). In adequate captive settings, animals acquire extensive histories of reinforcement from human caregivers and become sensitive to caretaker attention in response to certain behaviors. Dyadic play between domestic dogs is directly correlated with conspecific attention (Horowitz, 2009); it is possible that interspecific attention may be an environmental variable maintaining positive social interactions, including conspecific play in the present study.

Because the aim of the present study was to evaluate an extant husbandry strategy at a single facility, we had a limited ability to manipulate variables that could have contributed to a more functional analysis of play behavior in this population. This is a valuable area for future research that would be useful in addressing basic questions surrounding both the function of play and captive management issues in applied settings.

It is important to note that although the results of this study suggest that human interaction was enriching for these subjects, this is unlikely to be the case for all captive wolves and wolf–dog crosses. First, only socialized individuals were used in this study to ensure the safety of the human caretakers. However, many exotic animals arrive at sanctuaries through confiscation, often because they have been previously abused or neglected. Consequently, a substantial proportion of animals living in sanctuaries are not well socialized but show fear or aggression toward humans. Such animals are unlikely to respond as positively to humans entering their enclosures, even if such a strategy were considered safe for the caretakers involved. To make human interaction an effective form of enrichment for more individuals, future research should explore interventions to reduce both fear and aggression as well as promote affiliative behaviors in relatively nonsocialized animals. This would be hugely beneficial for management purposes in any facility providing long-term residence to captive animals.

CONCLUSION

The suitability of free-contact interactions between human caregivers and nondomesticated or exotic animals in captivity will likely be a subject of ongoing debate. In this case, we were able to evaluate a currently existing husbandry strategy in which experienced caretakers could interact safely with the animals, and we were able to ultimately provide systematic data on the effectiveness of this strategy. Although the generality of our findings is limited by a relatively small sample size, we hope that these findings prompt a larger-scale study examining whether human interaction is enriching for captive canids at other facilities, with caretakers who have had a variety of experiences and various types of interactions (e.g., passive interactions outside of the enclosure). We hope that future evaluations of human interaction will continue, but only where the safety and welfare of both species is upheld.

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REFERENCES

Baker, K. C. (2004). Benefits of positive human interaction for socially housed chimpanzees. *Animal Welfare*, *13*, 239–245.

Baker, K. C., Bloomsmith, M., Griffis, C., & Gierhart, M. (2003). Self-injurious behavior and response to human interaction as enrichment in rhesus macaques. *American Journal of Primatolology*, *60*, 94–95.

Baker, K. C., Bloomsmith, M. A., Neu, K., Griffis, C., & Maloney, M. A. (2010). Positive reinforcement training as enrichment for singly housed rhesus macaques (*Macaca mulatta*). *Animal Welfare*, *19*, 307–313.

Bassett, L., Buchanan-Smith, H. M., McKinley, J., & Smith, T. E. (2003). Effects of training on stress-related behavior of the common marmoset (*Callithrix jacchus*) in relation to coping with routine husbandry procedures. *Journal of Applied Animal Welfare Science*, *6*, 221–233.

Bergamasco, L., Osella, M. C., Savarino, P., Larosa, G., Ozella, L., Manassero, M., ... Re, G. (2010). Heart rate variability and saliva cortisol assessment in shelter dog: Human–animal interaction effects. *Applied Animal Behaviour Science*, *125*, 56–68.

Bloomsmith, M. A., Laule, G. E., Alford, P. L., & Thurston, R. H. (1994). Using training to moderate chimpanzee aggression during feeding. *Zoo Biology*, *13*, 557–566.

Broom, D. M. (1986). Indicators of poor welfare. *British Veterinary Journal*, *142*, 524–526.

Busch, R. H. (2007). *The wolf almanac: A celebration of wolves and their world.* Guilford, CT: Lyons.

Claxton, A. M. (2011). The potential of the human–animal relationship as an environmental enrichment for the welfare of zoo-housed animals. *Applied Animal Behaviour Science*, *133*, 1–10.

Coppola, C. L., Grandin, T., & Enns, R. M. (2006). Human interaction and cortisol: Can human contact reduce stress for shelter dogs? *Physiology & Behavior, 87*, 537–541.

Cordoni, G. (2009). Social play in captive wolves (*Canis lupus*): Not only an immature affair. *Behaviour*, *146*, 1363–1385.

Cusdin, P. A., & Greenwood, M. A. (2000). *The keeping of wolf-crosses in Great Britain.* West Yorkshire, UK: Royal Society for the Prevention of Cruelty to Animals.

Held, S. D. E., & Spinka, M. (2010). Animal play and animal welfare. *Animal Behaviour*, *81*, 891–899.

Horowitz, A. (2009). Attention to attention in domestic dog (*Canis familiaris*) dyadic play. *Animal Cognition*, *12*, 107–118.

Hoy, J. M., Murray, P. J., & Tribe, A. (2009). Thirty years later: Enrichment practices for captive mammals. *Zoo Biology*, *29*, 303–316.

Hubrecht, R. C., Serpell, J. A., & Poole, T. B. (1992). Correlates of pen size and housing conditions on the behaviour of kennelled dogs. *Applied Animal Behaviour Science, 34*, 365–383.

Johnston, J. M., & Pennypacker, H. S. (2008). *Strategies and tactics of behavioral research*. (3rd ed.). New York, NY: Routledge.

Laule, G. E., Bloomsmith, M. A., & Schapiro, S. J. (2003). The use of positive reinforcement training techniques to enhance the care, management, and welfare of laboratory primates. *Journal of Applied Animal Welfare Science, 6*, 163–173.

Maloney, M. A., Baker, K. C., Griffis, C., Neu, K., Bloomsmith, M. A., & Martinez, M. (2007). Behavioral responses by singly housed rhesus macaques (*Macaca mulatta*) during positive reinforcement training and human interaction. *American Journal of Primatology*, *69*, 119–120.

Manciocco, A., Chiarotti, F., & Vitale, A. (2009). Effects of positive interaction with caretakers on the behaviour of socially housed common marmosets. *Applied Animal Behaviour Science, 120*, 100–107.

Normando, S., Corain, L., Salvadoretti, M., Meers, L., & Valsecchi, P. (2009). Effects of an enhanced human interaction program on shelter dogs' behaviour analysed using a novel nonparametric test. *Applied Animal Behaviour Science*, *116*, 211–219.

Schapiro, S. J., Bloomsmith, M. A., & Laule, G. E. (2003). Positive reinforcement training as a technique to alter nonhuman primate behavior: Quantitative assessments of effectiveness. *Journal of Applied Animal Welfare Science*, *6*, 175–187.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. New York, NY: Houghton Mifflin.

Shepherdson, D. (1998). Tracing the path of environmental enrichment in zoos. In D. J. Shepherdson, J. D. Mellen, & M. Hutchins (Eds.), *Second nature: Environmental enrichment for captive animals* (pp. 1–12). Washington, DC: Smithsonian Institution Press.

Tarou, L. R., & Bashaw, M. J. (2007). Maximizing the effectiveness of environmental enrichment: Suggestions from the experimental analysis of behavior. *Applied Animal Behaviour Science*, *102*, 189–204.

Waitt, C., Buchanan-Smith, H. M., & Morris, K. (2002). The effects of care-taker–primate relationships on primates in the laboratory. *Journal of Applied Animal Welfare Science*, *4*, 309–319.

Wells, D. L. (2009). Sensory stimulation as environmental enrichment for captive animals: A review. *Applied Animal Behaviour Science*, *118*, 1–11.

Winer, B. J. (1971). *Statistical principles in experimental design* (2nd ed.). New York, NY: McGraw Hill.