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# Enhancement of Attachment and Cognitive Development of Young Nursery-Reared Chimpanzees in Responsive Versus Standard Care

**ABSTRACT:** *Forty-six nursery-reared chimpanzee infants (22 females and 24 males) receiving either standard care (n = 29) or responsive care (n = 17) at the Great Ape Nursery at Yerkes participated in this study. Standard care (ST) consisted primarily of peer-rearing, with humans providing essential health-related care. Responsive care (RC) consisted of an additional 4 hr of interaction 5 days a week with human caregivers who were specially trained to enhance species-typical chimpanzee socio-emotional and communicative development. At 9 months, ST and RC chimpanzees were examined with the Bayley Scales for Infant Development to assess their Mental Development Index (MDI). At 12 months, the chimpanzees were assessed with their human caregivers in the Ainsworth Strange Situation Procedure (SSP). In this first study to use the SSP in chimpanzees, nursery-reared chimpanzees exhibited the definite patterns of distress, proximity seeking, and exploration that underpin the SSP for human infants. In ST chimpanzees the attachment classification distribution was similar to that of human infants raised in Greek or Romanian orphanages. RC chimpanzees showed less disorganized attachment to their human caregivers, had a more advanced cognitive development, and displayed less object attachment compared to ST chimpanzees. Responsive care stimulates chimpanzees' cognitive and emotional development, and is an important factor in ameliorating some of the adverse effects of institutional care. © 2008 Wiley Periodicals, Inc. Dev Psychobiol*

***Keywords:*** *attachment; primate; parental care; early experience*

## INTRODUCTION

Attachment between mother and infant is part of the evolutionary heritage of mammals (see Panksepp, 1996),

with life-long filial bonds having evolved in the primate lineage. Many features of the attachment system as proposed by Bowlby (1969) are similar in old world monkeys, apes, and humans, suggesting that the design, ontogeny, and adaptive functions of attachment evolved in the approximately 35 million years since the split from the new world monkey lineage (see, e.g., Yerkes & Tomilin, 1935). Here, we document the outcomes of an quasi-experimental intervention to enhance attachment security and cognitive development in young nursery-reared chimpanzees. The intervention is not unlike various attachment-based interventions effectively enhancing attachment and cognitive development in human orphans

(e.g., Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2008; McCall et al., 2008).

## The Value of the Primate Model

Comparative (intervention) studies of attachment across primate species are useful for a variety of reasons (Maestripieri, 2003a,b). Strong attachment bonds between mother and infant are evident in rhesus monkeys (the most widely researched Old World Monkey), as shown by the separation studies of Harlow and his colleagues (Harlow & Harlow, 1965; Suomi, 1999, 2005), and by the observational studies of monkey infant development by Hinde and his colleagues (see Hinde, 2005). These studies determined the importance of contact comfort rather than food in the establishment of attachment (e.g., Harlow & Harlow, 1965; Mineka & Suomi, 1978) and, in fact, formed the evolutionary basis of Bowlby's (1969) attachment theory (Suomi, Van der Horst, & Van der Veer, 2008).

Moreover, comparative studies may be essential in determining characteristics or processes unique to the human species. Separation studies illustrate commonalities across old world monkeys, great apes, and humans in the initial protest phase, and the subsequent despair phase of longer term separation. However, only great apes and humans exhibit the "detachment" phase of the separation reaction (e.g., Bard & Nadler, 1983; Bowlby, 1969; Heinicke & Westheimer, 1965; Mineka & Suomi, 1978; Nadler & Green, 1975). Since great apes and humans exhibit complex sensori-motor intelligence that is not found in monkeys (e.g., Suddendorf, 2006), these studies provide evidence that advanced cognitive development may be necessary for the display of the complete sequence of attachment and separation responses.

## Standard and Responsive Care

In the early 1990s, a new philosophy of Responsive Care (RC) for raising infant chimpanzees separated from their biological parents was incorporated at the Great Ape Nursery at Yerkes Regional Primate Research Center (Bard, 1996). For young infant chimpanzees, the focus of the RC nursery was on meeting emotional needs by providing sensitive care that nurtured chimpanzee species-typical socio-emotional and communicative skills (Bard et al., in preparation; Van Lawick-Goodall, 1968). Here, we present the effects of this intervention program on attachment and cognition of 1-year-old chimpanzee infants receiving either Standard Care (ST) or Responsive Care (RC).To our knowledge, the current study is the first to investigate individual differences in attachment relationships in great apes (Maestripieri, 2003b, p. 131).

The only other study on individual attachment differences in nonhuman primates concerned Japanese macaques (Kondo-Ikemura & Waters, 1995). It is also the first intervention study with nonhuman primates evaluating the effects of two types of human care, differing in quantity and quality of caregiver interactions, on infant chimpanzees' cognitive development and attachment security.

## Individual Differences in Attachment Observed in the Strange Situation Procedure

Attachment behavior has the predictable outcome of increasing proximity of the infant to the attachment figure, usually the mother (Bowlby, 1969). In their first year of life, most human infants develop an organized attachment strategy to deal with the strains and stresses of separations, strange environments, illness, and other stressful or threatening events. The Strange Situation Procedure (SSP: Ainsworth, Blehar, Waters, & Wall, 1978) was designed to stress the attachment system in human infants in order to illuminate individual differences in the quality of attachment. In the SSP children are confronted with an unknown environment (a laboratory playroom), a stranger, and two brief separations from the caregiver. Investigations on individual differences in patterns of attachment behaviors of nonhuman primates in the SSP are absent (Maestripieri, 2003b, p. 131), although a Q-sort method has been used by Kondo-Ikemura and Waters (1995) in their study on individual attachment differences in Japanese macaques. An important aim of the current study is to evaluate whether the SSP is a useful setting for measuring attachment in nursery-reared chimpanzee infants. We expect chimpanzees to exhibit a balance of exploration of the environment and proximity seeking after separation and distress, uniquely preserved for the caregiver instead of a stranger, pointing to the favorite human caregiver functioning as a specific attachment figure.

***Organized and Disorganized Attachments.*** Upon reunion with the caregiver human infants may display one of three organized patterns of attachment (Ainsworth et al., 1978). Insecure-avoidantly attached children (about 20% of the cases) tend to minimize attachment behavior and focus on exploration despite their distress, whereas insecure-ambivalently attached children (about 15%) maximize attachment without being comforted by the contact with their attachment figure. Securely attached children (about 65%) strike the optimal balance between attachment behavior and exploration. Parental sensitivity is generally regarded as the single most important determinant of infant attachment security, particularly

for these three organized attachment strategies (Ainsworth et al., 1978; Bowlby, 1969; Pederson & Moran, 1995). The results of observational and experimental studies (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003) have confirmed the idea that sensitive responsiveness to a child's attachment signals is significantly and causally related to infant attachment security. In chimpanzees' infants, the enriched environment of responsive care is expected to enhance attachment security.

Whereas secure as well as insecure avoidant or insecure ambivalent attachment relationships can be considered *organized* strategies, adaptive to the child's (sometimes suboptimal) environment, some attachment relationships appear to be characterized by the absence or breakdown of an otherwise organized strategy, hence defined as *disorganized* (Main & Solomon, 1990). Disorganized attachment is found in about 15% of the nonclinical human infants, and is related to parents' unresolved loss or other trauma in these samples (Van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999). Indices of disorganized attachment behavior as expressed in the SSP are, for example, sequential or simultaneous display of contradictory behaviors, such as simultaneous display of distress and avoidance; stereotypies and anomalous movements or postures; and freezing or stilling behaviors, displayed (only) in the presence of the attachment figure (Main & Solomon, 1990). In samples of abused or neglected children, a disproportionate number of infants appears to be classified as disorganized attached (e.g., Cicchetti & Barnett, 1991). The structural neglect of traditional institutional care may cause an increase in the prevalence of disorganized attachments, not only in human infants (Vorria et al., 2003; Zeanah, Smyke, Koga, & Carlson, 2005) but also in nursery-reared chimpanzees. We hypothesized that responsive care would decrease the risk for attachment disorganization in comparison with standard care.

***Attachment to Objects.*** In the chimpanzee nurseries at Yerkes, cloth towels were given to all infants from birth through the first year of life. In the absence of a continually available caregiver or responsive attachment figure, chimpanzees might use soft objects such as "security blankets" to fulfill the role of surrogate attachments. Studies by McCulloch (1939a,b,c) demonstrated that paper toweling functioned as an attachment object for an infant chimpanzee: it was a desired object, when absent caused distress, and when present allowed for exploration. One of the aims of the current study is to examine whether object attachment is over-represented in standard care where caregiver absence was most profound compared to responsive care.

***Cognitive Development in Institution-Reared Infants.*** The studies of Vorria et al. (2003), Nelson et al. (2007), and McCall et al. (2008) showed the detrimental influence of orphanages on the cognitive development of infants reared in residential group care. In these studies, the residential children lagged substantially behind in cognitive development as assessed with the Bayley Scales for Infant Development. Although in orphanages books and toys are available, the caregivers only have time for basic physical care, and hardly interact with the babies in a stimulating way. In the current study on nursery-reared infant chimpanzees a central issue is whether enrichment of the institutional environment through responsive care may ameliorate the detrimental effects on cognitive development, as has been documented for human infants (Bakermans-Kranenburg et al., 2008).

## METHODS

### Subjects

Forty-six chimpanzee infants (22 females and 24 males) participated in this study. Most of the infants were born to mothers who did not have adequate maternal competence (as a result of inadequate experience with infants when they were young: Bard, 2002). Many of them were placed in the nursery because their mothers did not provide any cradling support ($n = 37$, 20 females) although some stayed with their biological mother for less than 30 days ($n = 6$, 1 female), and a smaller number of infants were placed in the nursery within the first 12 weeks of life ($n = 3$, 1 female). Infants arriving weeks after birth usually suffered some injury (bitten lips, fingers, or feet) or were otherwise at risk of survival (dehydration from lack of adequate nursing, overgrooming, poor health).

Once in the nursery all chimpanzees were raised following standard YRPRC nursery-care procedures (see below) but 17 subjects received an additional 4 hr of responsive care every Monday through Friday from specially trained human caretakers from birth through the first year of life (see below and Bard, 1996). Bayley tests were conducted on all nursery chimpanzees monthly from 3 to 12 months (see Bard & Gardner, 1996). In the current report, the assessment at 9 months of age was used because at this age human and chimpanzee infants appear developmentally most similar (Bard & Gardner, 1996). Attachment data were collected on 46 subjects at 12 months of age using the Strange Situation Procedure (Ainsworth et al., 1978) the most widely used test of attachment with human infants of the same age.

### Nursery Care

From 1956 through the late 1960s, some infant chimpanzees at Yerkes were raised in conditions of extreme deprivation from birth through 2 years of age. Isolation-rearing produced individuals with severe and persistent stereotyped behavior (rocking, self-clasping, eye poking, etc.: Davenport & Menzel,

1963), and with persistent cognitive, social, and sexual deficits (e.g., Menzel, 1964; Rogers & Davenport, 1969). In the Yerkes nursery of the late 1970s and early 1980s, chimpanzees were raised in pairs or triads. Infants developed strong and persistent peer attachments (e.g., Bard & Nadler, 1983), and the most severe stereotypies and social/sexual deficits were no longer evident.

***Standard Care.*** With a new focus on well-being (e.g., Fritz & Fritz, 1985), the Yerkes nursery of the late 1980s consisted of larger social groups, formed from the first months of life. The standard care practiced during this period differed from the pair-reared nursery as there were usually four to six infants in the social group. Human caregivers interacted daily with the infants. Standard care was given to all newborn chimpanzees placed in the nursery from 1987 to 1991, and, from 1987 to 1995, to all infants who were placed in the nursery late (more than 24 hr after birth). Standard care consisted primarily of peer-rearing, with staff providing essential heath-related care (feeding, diaper changes, health checks, etc.) on a regular schedule amid their other duties of cleaning and veterinary assistance.

In the first year, every 4 hr staff changed diapers and then fed infants a bottle of milk, usually while holding them for 15–20 min. Approximately four staff members were responsible for the care of 15–20 chimpanzees. Infants spent the majority of their time (from 4 pm until 10 am) in a padded cage with up to five other infant chimpanzees and with rolled towels (to cling to and for extra padding). Initially, single cages (1 m in length, height and depth) were used, but double or triple cages were used as the infants started to crawl (by 3–4 months). When the infants were 3 months, they were placed into different areas from 10 to 4 each day; at 4 months of age, they were put in a playpen in the hallway; at 5 months, the playpen was put inside a large room; at 7 months, the playpen was removed and a plastic climbing structure was added; at 8–9 months, they were moved into a larger dayroom. From 6 or 7 months each chimpanzee group would be visited by nursery staff for an hour of play after lunch. When the chimpanzees were approximately 1 year of age, diapers were removed permanently, all towels were removed permanently, and they no longer received milk in bottles. Shortly thereafter, the chimpanzee infants were moved to an outdoor enclosure for the first time.

***Responsive Care.*** Responsive care was given to all chimpanzees placed at birth in the nursery during the years from 1991 to 1995. For 4 hr each day (Monday through Friday), from 1 pm to 5 pm, all chimpanzees younger than 1 year of age were given sensitive care appropriate to their age and ability by a specially trained human research assistant. There were five trained assistants for three to five infants, although only three of them worked every day. A record was kept of infant and caregiver activity every 5 min, to ensure that responsive care infants experienced play, grooming, resting, and feeding at approximately the same levels as mother-raised infants at Yerkes (see Bard, 1996 for details). Daily summaries were made of major developmental milestones in motor skills, vocalizations, gestures, and social skills (Bard et al., in preparation; Veira &

Bard, 1996), which maintained staff focus on chimpanzee socio-emotional communicative development.

In the first 3 months, caregivers focused on infant's early motor development, encouraging each infant to develop strength in arms and legs. From 3 months, they nurtured communication, focusing on developing increasingly sophisticated competence in initiating and reciprocating social behaviors primarily with conspecifics, but also with humans (Bard et al., in preparation). From 6 months, caregivers focused on coping with novelty and regulation of fear and distress. There was an explicit program of managing distress reactions by considering novelty as an opportunity for exploration, and meeting challenges with curiosity rather than distress.

***Cohort Effects.*** There were no differences between RC and ST chimpanzees in birth weight, nor in neurobehavioral integrity (NBAS cluster scores of Orientation, Motor Performance, Range of State, State Regulation, and ANS Stability) at day 2, or at day 30, or at week 12. Additionally, there were no differences in socio-cognitive measures (BSID outcomes of Mental Development Index, Task, Affect, Activity, Coordination, and Audio-visual Reactivity) at 3 months or at 4 months (all $p$ values greater than .05; all partial $\eta^2$ values less than .11). There were no significant main effects of gender, or significant interactions of gender and group on any of these measures (all $F$ values less than 1.3, $p$ values greater than .15, all partial values less than .04). Thus, there was no evidence for initial differences between the cohorts receiving standard care or responsive care.

## Measures

***Bayley Scales for Infant Development (BSID).*** The BSID (Bayley, 1969) is an individually administered examination that assesses the developmental functioning of infants and children ages 3–42 months. The examination consists of age-appropriate situations and tasks designed to produce an observable set of behavioral responses. The Mental Development Index (MDI) is computed from raw scores and represents the child's level of cognitive, language, and personal-social development (Bayley, 1993). Like IQ scores, the MDI scores are statistically normalized, which means that the score for a typically developing human infant is 100 ($SD = 16$); higher scores indicate more advanced cognitive development.

Testing procedures at Yerkes and modifications of the BSID for use with chimpanzees is explained elsewhere (Bard & Gardner, 1996). The most important modification was that chimpanzees were not penalized for failing language items that are not part of their natural repertoire (they were given a "generous" score by discounting the failed language items), but the strictly scored MDI and the generous scores were strongly associated, $r = .97$ ($n = 40$). In the current study, reliability for MDI scores was assessed between a certified BSID examiner and one trained to administer the BSID with chimpanzees. Agreement was 100%, based on whether each administered item was passed or failed. In our sample, the MDI test-retest reliability across a 2-month period was $r = .75$ ($n = 34$). For four

chimpanzees the 9-month MDI score was missing but MDI scores were available at 8 months (for two) or at 10 months (for two). Therefore, analyses were based on the standardized 9-month MDI scores, with standardized 8- or 10-month MDI scores replacing the missing values.

***Object Attachment.*** The Infant Behavior Record from the BSID was also used to assess individual differences in attachment to a specific object. At the time of testing, a yes or no judgment was made about whether the infant exhibited an object attachment during the examination. Nineteen chimpanzees (41%) were attached to an object (a towel or blanket), whereas 27 (59%) chimpanzees were not. There was no association between gender and object attachment, $\chi^2$ (1, $N = 46$) = .30, $p = .77$.

***Strange Situation Procedure (SSP).*** The young chimpanzee was observed in the SSP (Ainsworth et al., 1978) with his or her favorite caregiver. The testing room was a novel setting, and the stranger was a human adult without familiarity with these chimpanzees. Fifteen different persons participated as favorite caregivers. Seven different persons participated as the stranger. There was no systematic effect of favorite caregivers or of stranger on attachment classification (all $p$s > .10).

The SSP consisted of eight episodes, each approximately 3 min in duration. As in the Ainsworth et al. (1978) procedure, the first episode was when the experimenter escorted the caregiver and infant into the novel room and reviewed the general procedures (no data were collected during this episode, and it was not used for analyses). The second episode was spent by the caregiver and the young chimpanzee in the novel setting with some familiar and some novel toys. In the third episode an unfamiliar adult (the ''stranger'') entered the room, in the 2nd minute talked with the caregiver, and in the 3rd minute initiated play with the chimpanzee. The fourth episode started when the caregiver departed, and the infant was left with the stranger. In the fifth episode the caregiver returned, and the stranger left. The sixth episode started when the caregiver departed again: the chimpanzee was alone in the room. In the seventh episode the stranger returned. In the eighth and final episode, the stranger left and caregiver and chimpanzee were reunited once again. Episodes were shortened if the caregiver indicated that the chimpanzee displayed substantial distress (episode 4 lasted at average of 2.1 min, and episode 7 lasted an average of 2.0 min), or extended if the experimenter indicated that the chimpanzee needed more time to settle (episode 2 lasted an average of 7.8 min, episode 5 lasted 4.6 min, and episode 8 lasted 3.7 min), in accord with administrative guidelines (Ainsworth et al., 1978).

Two types of distress reactions, crying and stereotypies, were coded from the videotaped observation. For vocalizations, one of six mutually exclusive and exhaustive (Bakeman & Gottman, 1997) codes was given to each 5-s interval: whimpering (calls of fussiness or mild distress), crying (extended calls of moderate distress), screaming (extended calls of intense distress), non-distress vocalizations, unsure/unclear, and no vocalization (see Bard, 1998, 2004, for more details of distress vocalizations). For analyses, the percentages of time in crying and screaming were summed. Each 5-s interval was also classified with one of the eight stereotypy codes, including thumb sucking; rocking; self-clasping; clasping towel; clasping and rocking; sucking and rocking; not visible or unsure; no stereotypies. The intervals in which rocking occurred, alone or in combination with other stereotypies, were summed for analyses.

Contact was coded continuously from the same videotaped observations with ten mutually exclusive and exhaustive categories, consisting of contacting (1) favorite caregiver, (2) stranger, (3) toys, (4) door, (5) favorite caregiver's chair, (6) other aspects of the environment like cage mesh, (7) cloth or towel, (8) not visible or unclear; (9) favorite caregiver and toys; and (10) stranger and toys. Interobserver agreement was also high: percent agreement 91%, Cohen's $\kappa$ .87. Contact with toys was used as an index of exploratory play. Contact with a cloth or towel was recorded only when the chimpanzee was clutching a cloth or towel to their body.

Four patterns of attachment were classified following the detailed guidelines in the Ainsworth et al. (1978) coding system. Chimpanzees who actively sought proximity to their caregivers upon reunion, showed their feelings of distress openly, but calmed down after being reassured by the caregiver, and in due course returned to exploration were classified as securely attached. Chimpanzees who ignored or avoided the caregiver following reunion were classified as insecure-avoidant. Chimpanzees who combined strong proximity seeking and contact maintaining with contact resistance, or who remained inconsolable without being able to return to play and explore the environment were classified as insecure-ambivalent. The absence or breakdown of an otherwise organized attachment strategy was observed in chimpanzees classified as disorganized (Main & Solomon, 1990). It was apparent from, for example, the sequential or simultaneous display of contradictory behaviors, freezing, or misdirected attachment behavior. Intercoder reliability between two independent and highly experienced coders (MvIJ, MB-K) for the four classifications was 95% ($\kappa = .87$, $n = 19$).

## Analyses

We first examined the validity of the Strange Situation Procedure in this sample of chimpanzee infants in captivity by testing through repeated measures analysis of variance whether the procedure was sufficiently stressful to elicit attachment behaviors, and whether it elicited differential attachment behavior to caregiver versus stranger. With analyses of variance and $t$-tests we also examined the behavioral differences between the various attachment classifications and between infants classified as disorganized and the other infants in terms of their simultaneous display of stress (e.g., rocking) and lack of proximity and contact seeking during the reunion episodes. Finally, with a multivariate analysis of variance we tested the effectiveness of the responsive care arrangement compared with the standard care setting on the four major outcome variables: cognitive development, disorganization and security of attachment to caregiver, and attachment to objects. In order to control for possible gender differences we added gender as the second factor.
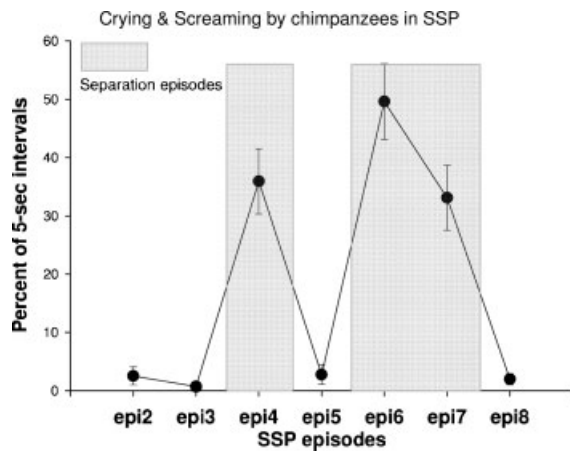
## RESULTS
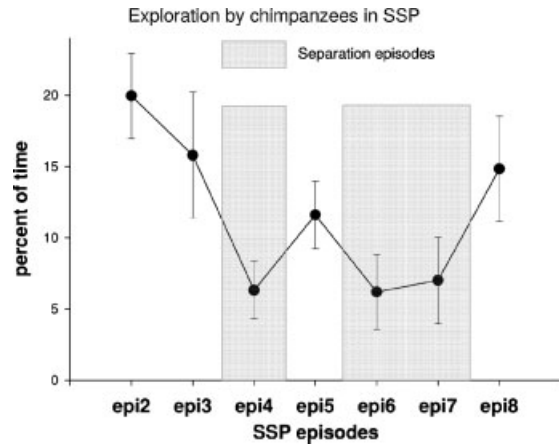
### Preliminary Analyses of the SSP

***Crying and Exploration During the Strange Situation Procedure.*** In order to examine whether the Strange Situation Procedure was sufficiently stressful, in particular in the episodes without the caregiver, we conducted a repeated measures analysis of variance on percentage of crying per SSP episode. The multivariate effect of episode was significant, $F(6, 258) = 39.70$, $p < .01$, $\eta^2 = .48$. In the episodes without the caregiver (episodes 4, 6, and 7) there was significantly more crying (see Fig. 1).

Second, we examined explorative play throughout the SSP. When the caregiver was present, subjects showed significantly more play behavior as apparent from percentage of the time that they touched the various toys available. The multivariate effect of episode was significant, $F(6, 222) = 3.52, p < .01, \eta^2 = .09$. Significantly less play was shown in episode 4 compared to episode 5, and in episode 7 compared to episode 8 (see Fig. 2).

***Differential Attachment Behavior to Caregiver and Stranger.*** In order to examine differential attachment behavior to caregiver versus stranger, we conducted a repeated measures analysis of variance on touching the stranger in episode 4 and episode 7 versus touching the own caregiver in episode 5 and episode 8 (both in proportions of time of the total duration of the episode). The multivariate effect of episode was significant, $F(3, 111) = 40.82, p < .01, \eta^2 = .53$. The chimpanzees touched their favorite caregiver significantly more often in episode 5 ($n = 38$, $M = 57.65$, $SE = 4.01$) and episode 8 ($n = 38$, $M = 53.66, SE = 6.08$) compared to the percentage of time they touched the stranger in the preceding episodes (episode 4: $n = 38$, $M = 8.51$, $SE = 3.24$; episode 8: $n = 38$, $M = 12.57$, $SE = 3.67$: Fig. 3).

**FIGURE 2**   Explorative play with toys in the presence of the primary caregiver (M +/− SE).

### Classification of Chimpanzee Infants in the Strange Situation Procedure

In the sample of 46 chimpanzees, we found 33% secure attachment classifications, 2% insecure-avoidant, 4% insecure-ambivalent, and 61% disorganized attachment classifications. The attachment of three chimpanzees could not be classified in the traditional Ainsworth coding system. These Unclassifiable subjects (Hesse, 1999) differed significantly from the other subjects both in the amount of crying, $F(1, 42) = 9.56, p < .01, \eta^2 = .19$, and in the amount of play, $F(1, 36) = 4.46, p = .04, \eta^2 = .11$. Unclassifiable subjects showed very high levels of crying behavior (particularly in episode 4 and episode 6) and virtually no play throughout the procedure. The three Unclassifiable infants were included in the Disorganized category, as did Vorria et al. (2003) with their unclassifiable human infants. The distribution did not differ significantly across gender ($\chi^2$ (3, $N = 46$) = 2.73, $p = .63$). The distribution differed significantly from the distribution of

**FIGURE 1**   Distress in the absence of primary caregiver in the SSP (M +/− SE).
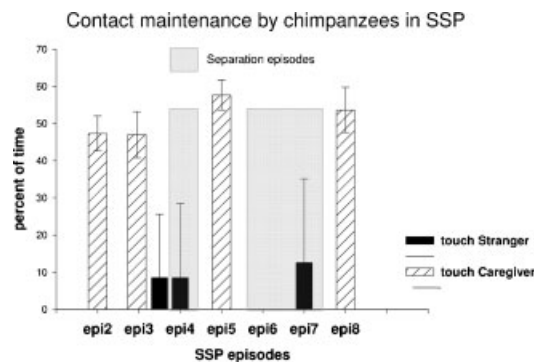
**FIGURE 3**   Differential contact with favorite caregiver versus stranger (M +/− SE).

the four attachment classifications in nonclinical infants (Van IJzendoorn et al., 1999), $\chi^2$ (3, $n = 46$) = 77.85, $p < .01$. Disorganized chimpanzees were overrepresented, and secure, avoidant, and ambivalent classifications were underrepresented among chimpanzees. If infant chimpanzees were forced-classified they appeared to be primarily secure (54%), with 7% insecure-avoidant, 33% insecure-ambivalent and 7% unclassifiable.

Excluding the Unclassifiable subjects, we found no difference in amount of crying in episodes 5 and 8 between the forced secure (B), insecure-avoidant (A), and insecure-resistant (C) classifications, $F(2, 39) = 1.61$, $p = .21$, $\eta^2 = .08$. Contrasts between B and A, and between B and C were not significant either. For explorative play (touching toys) the difference was significant, $F(2, 32) = 4.22$, $p = .02$, $\eta^2 = .21$. The contrast between B and C was significant ($p = .03$), as expected B subjects showed more play behavior in both reunions. Moreover, a significant interaction between classification and episode was found; insecure-avoidant chimpanzees showed an increase in play from episode 5 to 8 whereas B and C chimpanzees did not show such an increase (A vs. B, $p = .02$; A vs. C, $p < .01$). Insecure-avoidant infants are supposed to use their play increasingly during the reunion episodes in service of unobtrusively avoiding the caregiver even when they are stressed (Ainsworth et al., 1978).

In order to examine potential differences in the SSP between subjects classified as disorganized and subjects who were not classified as disorganized, we conducted a series of $t$-tests of rocking, crying, clutching towel, and touching the caregiver. Disorganized chimpanzee infants ($n = 26$) showed significantly more rocking than nondisorganized infants ($n = 18$) in both reunion episodes 5 ($t(26) = 4.20$, $p < .01$) and 8 ($t(25) = 4.46$, $p < .01$; unequal variances $t$-tests (Fig. 4). At the same time disorganized chimpanzee infants ($n = 21$) displayed less touching of the caregiver compared to nondisorganized infants ($n = 17$) in both episode 5, $t(36) = 1.70$, $p = .10$, and episode 8, $t(36) = 2.85$, $p < .01$. Disorganized chimpanzee infants also displayed more clutching of the towel compared to nondisorganized infants in both reunion episodes, episode 5 ($t(36) = 2.69$, $p = .01$, and episode 8 ($t(36) = 2.53$, $p = .02$; unequal variances $t$-test (Fig. 5). The combination of stress behavior (rocking) without seeking relief with the caregiver (touching caregiver) seems characteristic of disorganized attachment in these chimpanzee infants. Crying did not differentiate between disorganized and the other infants.

## Cognitive Development

The mean score on the MDI in the chimpanzee sample was $M = 98.05$ ($SD = 25.77$). Female chimpanzees ($n = 20$,
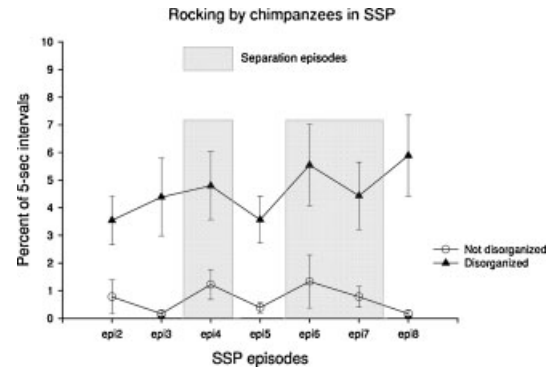


**FIGURE 4** Stereotyped rocking in the SSP shown by disorganized and not disorganized chimpanzees (M +/− SE).

$M = 93.85$, $SD = 24.36$) did not significantly differ from males ($n = 21$, $M = 102.05$, $SD = 27.01$), $t(39) = 1.02$, $p = .32$. The MDI scores of the 9-month-old chimpanzees were comparable to the MDI scores of 13-month-old institutionalized infants ($n = 82$, $M = 92.8$, $SD = 10.3$: Vorria et al., 2003) who were separated from their biological mother a few days after birth and reared in the group care setting of Metera, $t(121) = 1.26$, $p = .21$ (unequal variances), but also comparable to those of typically developing family raised 9-month-old human infants ($M = 100$, $SD = 16$).

## Effects of Standard Versus Responsive Care

In a multivariate analysis of variance with cognitive development, object attachment, and secure and disorganized attachment as dependent variables, and type of care and gender as factors, there was a significant multivariate effect for type of care, $F(4, 39) = 4.00$, $p < .01$ (29% explained variance). The multivariate main effect for gender ($p = .67$) and the multivariate interaction between intervention and gender ($p = .27$) were not significant (Box's test for equality of covariance matrices
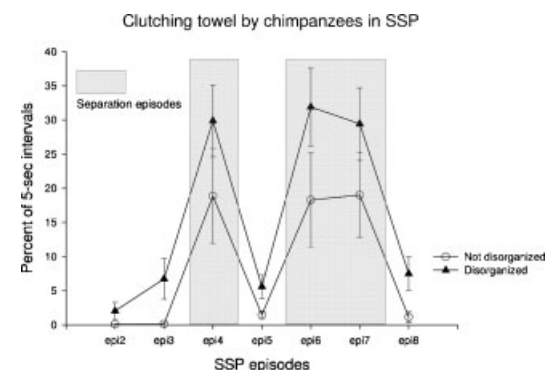


**FIGURE 5** Clutching of towels in the SSP shown by disorganized and not disorganized chimpanzees (M +/− SE).

**Table 1.  Cognitive Development, Attachment to Object, and Secure and Disorganized Attachment in Chimpanzees in Standard Versus Responsive Care**

| | Type of Care | | | | | |
| | Standard Care | | | Responsive Care | | |
| Outcome | N | M | SD | N | M | SD |
|---|---|---|---|---|---|---|
| Cognitive development (MDI) | 29 | −.24 | 1.16 | 17 | .45 | .60 |
| Attached to object | 29 | 59% | | 17 | 12% | |
| Securely attached | 29 | 52% | | 17 | 59% | |
| Disorganized | 29 | 72% | | 17 | 41% | |

was nonsignificant, Box's $M = 26.13$, $p = .38$). The tests of the between-subject effects on cognitive development ($F(1, 42) = 5.34$, $p = .03$, $\eta^2 = .11$), object attachment ($F(1, 42) = 11.92$, $p < .01$, $\eta^2 = .22$), and disorganized attachment ($F(1, 42) = 5.37$, $p = .02$, $\eta^2 = .11$) were significant. There was no main effect for secure attachment, and there were no interaction effects for type of care and gender on any of the four outcomes. The chimpanzee infants in responsive care were less often attached in a disorganized way, they showed less often attachment to objects, and they scored significantly higher on the Bayley scales for mental development (Tab. 1; Fig. 6).

On the level of the four-way classifications, in the group of standard care chimpanzees 28% were securely attached and 72% were disorganized, whereas in the responsive care group 41% were securely attached, 6% were insecure-avoidant, 12% were insecure-ambivalent, and 41% were disorganized. Because the chimpanzees in standard care were either secure or disorganized, the effect of responsive care on the level of the four-way attachment classifications could not be tested.
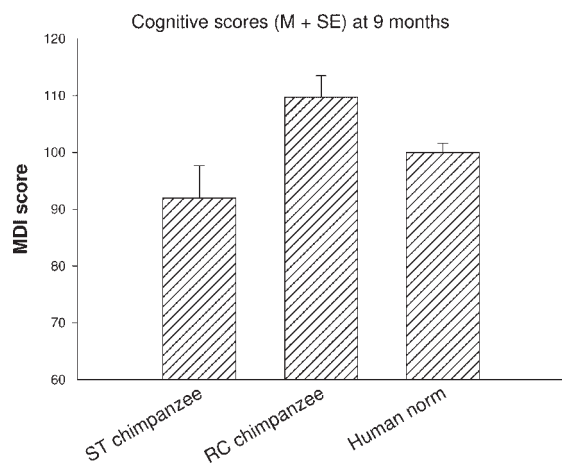
In standard care 59% of the chimpanzees were attached to an object, whereas in responsive care only 12% were attached to an object (see Tab. 1). The combination of attachment to an object and disorganized attachment to the human caregiver as an outcome variable showed a significant effect of the intervention, $\chi^2$ (3, $N = 46$) = 10.79, $p < .01$. Responsive care significantly increased the number of infants with an organized attachment to the caregiver without an attachment to an object (*adjusted standardized residual* = 2.3), whereas it significantly decreased the number of disorganized attachments combined with attachment to an object (*adjusted standardized residual* = −3.2).

## DISCUSSION

Nursery-reared chimpanzees, during the Strange Situation Procedure (SSP), exhibit the balanced patterns of distress and exploration that underpin the SSP for human infants (Ainsworth et al., 1978). The chimpanzees exhibited distress (crying and screaming) in those episodes when they were separated from their favorite caregiver, and exhibited exploration of the test room (touching toys) in those episodes when their favorite caregiver was present. Moreover, the chimpanzees differentiated their favorite caregiver from a stranger and preferred contact with their favorite caregiver.

The SSP triggers the attachment system of young chimpanzees to their favorite human caregivers similar to the SSP with human infants and their attachment figures. Expert coders trained on hundreds of human infant attachment SSP's were readily able to independently identify individual attachment patterns in chimpanzee infants with a high level of intercoder reliability. This is the first study that used the SSP with nonhuman primates (Maestripieri, 2003b, p. 131; see Kondo-Ikemura & Waters, 1995, for a study on attachment in Japanese macaques using the adapted Attachment Q-Sort). Although complex cognitive sequelae, such as adult working models of attachment, may well be uniquely



**FIGURE 6** Cognitive development in 9-month-old chimpanzees (standard care and responsive care) and the norm for humans (from Bayley, 1969).

human, the attachments of infant chimpanzees appear surprisingly similar to those of human infants. In fact, infant chimpanzees raised in human families have been noted to react in many ways as young children do (e.g., Kellogg, 1968)

The majority of nursery-raised 1-year-old chimpanzees (61% or 28 chimpanzees) showed distinct signs of attachment disorganization, including rocking, freezing, and clutching a towel at reunion rather than initiating proximity to the attachment figure when they were clearly distressed. In this respect, the chimpanzees were remarkably similar to human infants raised in Greek, Russian, or Romanian orphanages at least two-thirds of whom also showed attachment disorganization (McCall et al., 2008; Vorria et al., 2003; Zeanah et al., 2005). Obviously, drawing a parallel between nonhuman and human primates one runs the risk to humanize the chimpanzee and make too much of the direct comparison between their responses. We found that responsive care reduced the risk for attachment disorganization, and also led to fewer infants exhibiting object attachments. Emotional responsivity of caregivers is a critical factor in ameliorating some of the adverse effects of institutional care. The implication of this study is that chimpanzees may provide a useful animal model for the effects of early rearing on attachment (Maestripieri, 2003b).

## Cognitive Development

In comparison with normed human US samples, 9-month-old nursery-reared chimpanzees would be considered to show typical cognitive development, apart from the lack of language skills. Moreover, the chimpanzees' cognitive development was somewhat more advanced compared to Metera's institutionalized infants who were 4 months older (Vorria et al., 2003), suggesting that the institutionalized rearing was less severe for the chimpanzee. Similar levels of institutionalized care may more severely impact on human cognitive development than that of chimpanzees. Alternatively, the effects of institutionalized care may be more evident in chimpanzees at older ages. We favor the conclusion that the current nursery chimpanzees did not experience severe deprivation, and that only chimpanzees raised in isolation suffer long-lasting and more severe deficits in cognitive responses (e.g., Davenport & Rogers, 1970; Menzel, Davenport, & Rogers, 1970).

When given institutionalized care (e.g., too few caregivers, and/or caregivers who are overburdened with other work), chimpanzees as well as human children suffer some deficits in cognitive development. In the Metera nursery, infants spent on average $17\frac{1}{2}$ hr alone and in a cot (Vorria et al., 2003). Nursery-raised chimpanzees also spent the majority of their time without adult caregivers (ST about 75%; RC about 65%), however, these chimpanzee infants were never alone; they lived continuously in a group of four to six other chimpanzees. The care environment of the nursery chimpanzees in ST care and the Metera orphanage children share some features, such as restricted interaction with caregivers, and daytime care primarily on a schedule. Ironically, it appears that the children's orphanages provided a more deprived type of institutional care than the responsive care arrangement of the chimpanzee nursery, with an accompanying larger negative impact on the children's cognitive development. The effect of the responsive care intervention on cognition nicely converges with recent reports on the efficacy of enhanced, individualized care in cases of abandoned or orphaned human infants (Bakermans-Kranenburg et al., 2008; McCall et al., 2008).

## Attachment to Objects

More than half of the nursery-raised chimpanzee infants did form attachments to objects (59% of chimpanzees in standard care). This prevalence of object attachment in chimpanzees is comparable to that of human infants. Attachments of human children to cuddlies and security blankets are a fairly common phenomenon in Western culture: 60% of the children in a sample of 690 American mothers (Passman & Halonen, 1979) and 57% of preschoolers in a Dutch survey among 352 mothers (Van IJzendoorn, Goossens, Tavecchio, Vergeer, & Hubbard, 1983) were found to be attached to an object. Children are in need of their favorite object when going to sleep, when tired or ill, while inactive, or during long-lasting trips and stays away from home, suggesting that particularly the caregiver's absence elicits the infants' cuddling of favorite blankets or toys. Indeed, cross-cultural studies indicate that in cultures where caregivers are continuously available, also during the night, children rarely get attached to objects (Hong & Townes, 1976).

Whereas studies on human infants concerned mother-reported object attachment, in our study object attachment was observed in a specific situation, the administration of the Bayley test, which may have resulted in an underestimation of the number of chimpanzees who formed attachments to objects. Moreover, studies on object attachment in human infants so far did not include institutionalized infants, precluding a comparison between chimpanzee and human infants in this regard. Responsive care reduced the likelihood that a nursery chimpanzee would form an object attachment. This was the case even though in order to enrich the environment a greater number and variety of towels were provided to responsive care infants than were provided to standard care infants. We believe that responsive care supported the development of more appropriate coping responses to stressful

situations, for example, seeking relief with a caregiver, thus enabling chimpanzees who experienced responsive care to better cope with the stress involved in the SSP.

## Disorganized Attachment and Structural Neglect

A relatively high proportion of nursery-raised chimpanzees were classified with disorganized attachment, in particular in the ST condition. Disorganized attachment is considered to be the most insecure type of attachment. Several studies have shown that in human offspring disorganized attachment in infancy is predictive of problematic stress regulation (Hertsgaard, Gunnar, Erickson, & Nachmias, 1995; Spangler & Grossmann, 1999), an elevated risk of externalizing behavior problems (e.g., Lyons-Ruth & Jacobvitz, 1999), lower emotional health at school age, and dissociation in adolescence (Carlson, 1998). A comprehensive meta-analysis examining 80 studies on disorganized attachment (Van IJzendoorn et al., 1999) documented significant associations of disorganized attachment with externalizing problems in school-age children.

Elevated rates of disorganized attachment in the chimpanzees may be caused by structural neglect that seems unavoidable in institutional care without one or more stable adult caregivers who take care of the offspring's needs day and night. Lyons-Ruth and Jacobvitz (1999) suggested that when the parent withdraws from the interaction by being (extremely) unresponsive to the needs of the infant, failing to terminate its attachment system, disorganized attachment may result (see also Solomon and George, 1999; for a meta-analysis, see Madigan et al., 2006). Structural neglect may have also caused the remarkable increase in the prevalence of disorganized attachments in institutionalized human infants (McCall et al., 2008; Vorria et al., 2003; Zeanah, Smyke, Koga, & Carlson, 2005). Adoption into families (Van IJzendoorn & Juffer, 2006) or experimentally induced foster care (Nelson et al., 2007) effectively lower the number of disorganized children. More personal care for infant chimpanzees in the responsive care intervention had a similar effect. Our present study also showed a relation between having an object attachment at 9 months and displaying disorganized attachment at 12 months in chimpanzee infants. Responsive care was successful at reducing the occurrence of object attachments, and at the same time reducing the level of disorganization in chimpanzees.

## Standard Versus Responsive Care

Responsive care for chimpanzees, designed to improve chimpanzee species-typical communication, had a

significant impact on improving cognition and improving attachment. The variety of experiences, in terms of encountering new events, was quite different. One of the major differences between standard care and responsive care was the quality of interaction with caregivers, although the amount of time with adult human caregivers varied as well. It is not known which of these factors, quality or quantity of caregiving, was primarily responsible for the developmental differences, as responsive care in fact should be considered a broadband and long-term intervention (Bakermans-Kranenburg et al., 2003; Bard, 1996; Bard et al., in preparation).

Nevertheless, we propose that by increasing sensitive caregiving to nursery chimpanzees, their cognitive development and their attachment relationships improved, and that a similar approach to stimulate responsive care in residential settings such as orphanages may be successful as well (see Groark, Muhamedrahimov, Palmov, Nikiforova, & McCall, 2005, and McCall et al., 2008, for an impressive intervention in Russian orphanages). Thus, this study documents the plasticity of development in nonhuman primates under drastically varying environments, and supports one of the core tenets of attachment theory, that sensitive care promotes secure attachments not only in human infants but also in infant chimpanzees.

## Limitations

The current study used a quasi-experimental design (Cook & Campbell, 1979), in which subjects were not assigned to ST or RC groups on a random basis. Systematic differences between the two groups at entry of their care arrangement might (partly) explain the differences found after about a year of care. It should be noted, however, that few differences were found in neonatal behavior between cohorts (Bard, Platzman, Lester, & Suomi, 2001) and the study did not involve selection of chimpanzee infants on any other ground than their birth cohort, being born in the period from 1987 to 1991 (ST) or from 1991 to 1995 (RC). We directly tested for cohort effects and found no group differences early in life. We also did not find systematic differences in the standard care practices of the Yerkes Nursery throughout the entire study period (1987–1995), negating the argument that changes in standard care practices could account for group differences. Many chimpanzees were genetically related across groups, making it less plausible that genetic differences between cohorts created the intervention effects. Therefore, we conclude that group differences found at 9 and 12 months are attributable to rearing and not to cohort effects.

The comparability of the chimpanzee institutional care arrangement with orphanages for human infants may be incomplete, as the human orphans were raised by conspecifics whereas the chimpanzees were raised by

human caretakers. In both cases however the infants are growing up in an environment that does not provide the average, species-specific expectable living conditions (Cicchetti & Valentino, 2006; Nelson et al., 2007). Stable, continuous relationships with a protective parent are lacking, and structural neglect of both the human and chimpanzee infants may not always have been avoided. Nevertheless, we should be cautious in drawing a developmental parallel between nursery-reared chimpanzees and human infants raised in orphanages as we still have insufficient knowledge of the specific developmental pathways of both groups.

## CONCLUSIONS

This is the first study to assess prospectively the effects of early rearing on individual differences in attachment in chimpanzees. For attachment to the caregiver, we found that responsive care was particularly effective in reducing the risk for attachment disorganization. Additionally, those infant chimpanzees who experienced responsive care had more advanced cognitive development than chimpanzees who experienced standard care, and they displayed less object attachment than standard care chimpanzees. In conclusion, responsive care in the first year of life positively stimulates chimpanzees' cognitive and emotional development.

## NOTES

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