

An Index of Relationship Quality Based on Attachment Theory

Ann Weaver

Emory University and
University of Colorado Health Sciences Center

Frans B. M. de Waal

Emory University

Two measures are reported of the nature or quality of a mother–offspring (MO) relationship during development using brown capuchin monkeys (*Cebus apella*) as models. One is a qualitative classification of MO relationships as secure, resistant, or avoidant attachments. The other is an empirical ratio of relative affiliation to agonism called the *MO relationship quality*, or MORQ, Index. The two methods tapped similar relationship features so relationships high or low of a median split of MORQ values were heuristically labeled secure ($n = 22$) or insecure ($n = 16$), respectively. A comparison revealed extensive behavioral differences between secure and insecure MO relationships and suggested MORQ provided an objective, continuous measure of attachment security.

Psychologists and primatologists have long appreciated the importance of understanding social relationships and have drawn extensively from nonhuman primates. Field studies of free-ranging chimpanzees (*Pan troglodytes*) showed that spontaneous social behavior was influenced by the quality of relationships between individuals (Goodall, 1967). Kummer (1982) demonstrated that relationships among free-ranging primates were key social investments that influenced their social organization, and Hinde (1979) provided a way to systematically study social relationships by analyzing the history of interaction between social partners in rhesus macaques (*Macaca mulatta*).

These and subsequent studies contrasted with earlier perspectives from laboratory studies that mother–offspring (MO) relationships were partisan social systems governed primarily by the changing needs of the infant (e.g., Harlow & Harlow, 1965). Many data from experimental separation of nonhuman primate mother–infant pairs, to document the behavioral and/or physiological consequences of separation for the infant, show that the presence of a mother has a critical influence on the extent to which the primate infant develops normally (Clarke, 1993; Clarke et al., 1996; Clarke, Kraemer, & Kupfer, 1998; Coe, Weiner, Rosenberg, &

Levine, 1985; Kraemer, Ebert, Schmidt, & McKinney, 1991; Laudenslager & Boccia, 1996; Laudenslager et al., 1995; Suomi, 1982).

The effects of separation depend on the extent of the separation (temporary privation through complete deprivation), infant age and species, and availability of social partners to alleviate the loss of the mother for the infant (Kraemer, 1992). Separated infants show immediate effects like dysregulated autonomic responses (Boccia, Reite, Kaemingk, Held, & Laudenslager, 1989). They show lasting deficits as subsequent abnormalities in core neurobiological functioning, for example, failing to develop the ability to organize emotional behavior when stressed (Clarke et al., 1996, 1998; Kraemer, 1985, 1992; Kraemer et al., 1991).

Milder separation paradigms that achieve greater ecological validity show chronic though subtler consequences for infant social development (Laudenslager & Worlein, 1998), including less play, fewer social partners, and less complex socializing in general (Caine, Earle, & Reite, 1983; Capitanio & Reite, 1984). Separated youngsters also often exaggerate their negative responsiveness to socially stressful situations (Boccia, Reite, & Laudenslager, 1991).

Although the impact of MO separation is more obvious in infants than in mothers, the MO relationship is like a bipartisan social system that mutually regulates the behavior and physiology of both the mother and the infant (Alberts & Gubernick, 1990; Clarke & Schneider, 1993; Hofer, 1987). In both human (Brazelton, Koslowski, & Main, 1974; Lester, Hoffman, & Brazelton, 1985; Stern, 1974) and nonhuman primates (Fairbanks & McGuire, 1987, 1993; Timme, 1995), the MO relationship develops from the most characteristic type of interaction between mother and young. The rhythm and timing of social interaction range from closely orchestrated synchrony to disruptive asynchrony, with a resultant impact on the nature of reciprocal stimulation the partners each experience (Hinde, 1969; Rosenblatt, 1994; Spangler, Schieche, Ilg, Maier, & Ackermann, 1994).

Consequently, there have been many attempts to identify and measure features that are pertinent to intact (nonseparated) MO pairs (Berman, 1980; Fairbanks & McGuire, 1987, 1993). One dimension that has emerged as important to the validity of a measure of relationship quality is to assess both partners' contri-

Ann Weaver, Living Links, Yerkes Regional Primate Research Center, Emory University, and Department of Psychiatry, University of Colorado Health Sciences Center; Frans B. M. de Waal, Living Links, Yerkes Regional Primate Research Center, Emory University.

This research was made possible by support from the National Science Foundation Grant IBN-9321195 to Frans B. M. de Waal, by Grant RR-00165 from the National Institutes of Health to the Yerkes Regional Primate Research Center, and by a fellowship to Ann Weaver from the American Association of University Women. The Yerkes Primate Center is fully accredited by the American Association for Accreditation of Laboratory Animal Care. We thank L. Parr and J. Christou for assistance with basic data collection and F. Aureli, S. Ekard, D. Fragaszy, M. Gouwens, H. Gouzoules, J. Heidemann, T. Insel, P. Rochat, and M. D. Weaver for inspiring discussion and for helpful comments on this article.

Correspondence concerning this article should be addressed to Ann Weaver, 6735 East Greenway Parkway, Suite 2043, Scottsdale, Arizona 85254-2113. E-mail: achweaver@att.net

butions to the relationship (Hinde, 1969) because they are interdependent (Rosenblum & Youngstein, 1974). Hinde and Atkinson (1970) showed the utility of an index that assessed the relative contribution of both mother and young in the development of infant independence. Fairbanks (1989) developed a similar Proximity Index to measure social development in vervet monkeys (*Cercopithecus aethiops*).

A second dimension that has emerged as pertinent to relationship quality is the use of opposite or polar ends of a continuum of an aspect of social behavior. For example, Sade (1965) studied affiliative and agonistic interactions among free-ranging Cayo Santiago rhesus macaques. Fairbanks and McGuire (1985) used a similar dichotomy to illuminate the influence of youngster sex and maternal rank on social relationships among vervets. More recently, study of the association of affiliation and agonism revealed new roles of kinship (Bernstein, Judge, & Ruehlmann, 1993a) and sex differences among rhesus macaques (Bernstein, Judge, & Ruehlmann, 1993b). An expanded application of behavioral opposites like grooming and aggression to research on MO relationships revealed four distinct maternal styles: protective, rejecting, controlling, or laissez-faire in chacma baboons (*Papio cynocephalus*; Altmann, 1980) and vervet monkeys (Fairbanks & McGuire, 1987). Fairbanks and colleagues then clearly demonstrated that youngsters emanating from relationships with different maternal styles were very different behaviorally (Fairbanks, 1989; Fairbanks & McGuire, 1988, 1993).

MO relationship quality is influenced by a number of factors like maternal dominance, parity, and infant sex. However, because the influence of these factors is highly variable both within and between nonhuman primate species, it is uncertain whether MO relationship research has detected true variability or whether it suffers the consequences of too many behavioral measures of relationships (Schino, d'Amato, & Troisi, 1995). This suggests that a third dimension should be considered in measuring MO relationship quality: the use of a smaller number rather than a larger number of ethologically meaningful behaviors.

To summarize up to this point, past research suggests that an ecologically valid measure of MO relationship quality should be based on a few ethologically meaningful social behaviors that are opposite in nature, are based on the interaction between members of an intact pair, and reflect both a mother's and her offspring's contribution to their relationship. The reliability of an MO relationship quality index with these features could then be examined against an existing theoretical framework about MO relationships.

Attachment theory (Bowlby, 1969) is one of the most influential and well validated theoretical frameworks about human MO relationships (Lamb, Thompson, Gardner, & Charnov, 1985) and is a good test for a measure of MO relationship quality. In humans, several types of MO attachments are revealed through a laboratory procedure called the Strange Situation (Ainsworth & Wittig, 1969), which assesses whether children are relatively secure or insecure in their MO relationship. The procedure draws on the idea that threats to the relationship, like a separation, elicit behavior that indicates the kind of attachment an infant feels to its mother. By exposing an infant's responses to a temporary separation from its mother and the additional social challenge of a strange adult, the Strange Situation reveals the quality of their relationship. Human infants who are frightened by separation but soothed by the return of their mothers are characterized as securely attached. Infants who

are inordinately distressed by the entire experience are characterized as resistantly attached, and infants who behave as if they never lost their mothers are characterized as avoidantly attached.

Infants show the same behavior toward their mothers in the Strange Situation as they do toward her at home in their 1st year of life (Ainsworth, Blehar, Waters, & Wall, 1978; Sroufe & Waters, 1977; Waters, 1978). This conclusion comes from the Baltimore Longitudinal Study (Ainsworth et al., 1978), one of the largest investigations of the antecedents of secure and insecure attachments. The Baltimore Study provided an extensive database on 26 middle-class families observed for 4 hr every 3 weeks for the 1st year of their infant's life.

The hypothesis that a human infant's secure or insecure attachment to its mother was influenced by their interactional history was tested by a comparison of naturalistic observations of the mother-infant relationship at home the 1st year of the infant's life (at-home behavior) with their behavior in the Strange Situation in the laboratory. The comparison showed that human infants who differed in their attachments, that is, were secure or insecure, had mothers whose behavior and attitudes differed in salient ways as early as the baby's first 3 months. Mothers of secure infants were characteristically better paced, more timely, more satisfying, and better rounded in social interactions with their infants. They were quantitatively more sensitive toward, accepting of, cooperative with, and accessible to their infants. In contrast, mothers of insecure infants were significantly less tender during physical contact, less affectionate, and less responsive to crying than mothers of securely attached infants (Table 20, Ainsworth et al., 1978, p. 149). Close examination of MO social interaction revealed that the pivotal maternal influence underlying secure and insecure attachments was maternal sensitivity.

Maternal sensitivity in the Ainsworth studies (Ainsworth, Bell, & Stayton, 1974; Ainsworth et al., 1978; Ainsworth & Wittig, 1969) used rating scales (e.g., Ainsworth et al., 1974) to document behavior along such continuums as acceptance-rejection, cooperation-interference, and accessibility-ignoring. The Baltimore Study data were collected as written narratives by pairs of observers (to avoid halo effects) and used to derive the Ainsworth scales retrospectively. The scales had the advantage of measuring relationships through the close examination of spontaneous interaction and capturing their tone and implication (instead of weighing everything equally as in frequency data). The scales' primary disadvantage was their subjectivity. The validity of the rating scales depended on observers' expertise with the pertinent behavioral repertoire and clinical acumen.

The aim of this study was to derive an empirical measure of relationship quality that drew on salient features of maternal and youngster behavior underlying the development of secure and insecure attachments while avoiding subjectivity. We drew information from the Baltimore Study about human children's at-home behaviors indicative of secure and insecure attachments, applied it to the spontaneous baseline behavior between capuchin mothers and their immature offspring, and identified analogous behavior to assess capuchin relationship quality. We sought a measure that was continuous rather than categorical, that was based on the interaction between mother and infant rather than isolated measures of the behavior of one or the other social partner, that was flexible enough to incorporate changes in the MO relationship over time,

and whose reliability could be tested against an existing theoretical framework.

Method

Subjects

Focal subjects were 24 brown capuchins (*Cebus apella*) at the Living Links Center, Yerkes Regional Primate Research Center, Emory University. The capuchins lived in a small building without other animals and were housed as two large groups in indoor-outdoor mesh enclosures, 30.9 and 25.2 m², respectively, outfitted with PVC shelves, swings, and wood shavings as substrate, freshened weekly. The outdoor section was about one third of the available space in the cage. The mesh enclosures ran parallel to each other but a heavy plastic liner hung between the two cages, allowing acoustic but not visual contact between them. The capuchins were provided with daily monkey chow, water, and produce ad libitum. They had full access to both indoor and outdoor areas of their cages, except during observation when they were locked inside to ensure that all capuchins had the same consistent chance of being observed.

During the study, composition of the study groups changed from births only. One group increased from 14 (2 adult males, 4 adult females, 4 immature females, 4 immature males) to 18 capuchins with the birth of 4 males. The other group increased from 16 (2 adult males, 5 adult females, 1 immature female, 8 immature males) to 21 capuchins with the birth of 5 males. All the capuchins were individually identifiable. Capuchins in the two groups were unrelated. Within each social group, MO pairs were the related capuchins.

Focal animal subjects were 24 youngsters ($n_{\text{Males}} = 19$, $n_{\text{Females}} = 5$) ranging in age from 3 months to 5 years from 9 mothers; the sample skew toward males precluded analysis of sex differences. Monthly nursing rates (bouts/hour) were visually inspected to divide youngsters into infant, weanling, and juvenile developmental stages according to the following criteria. Infants ($n = 12$) showed consistently high rates. Weaning ($n = 10$) began with the first substantial drop in nursing rates and was characterized by high variability. Juveniles ($n = 16$) did not nurse. Figure 1 provides an example: At age 7 months, the capuchin was considered an infant; from age 8 to 13 months, a weanling; and from the age of 14 months on, a juvenile. We used nursing rates (separate but imbedded in contact sitting rates) rather than youngster age; by grouping youngsters showing similar nursing patterns, we hoped to group youngsters whose mothers were in

similar phases of lactation and therefore similar stages of weaning their young from the nipple.

This developmental study combined longitudinal and cross-sectional approaches. Fourteen of the total 38 MO pairs contributed data to two or three developmental stages: 6 capuchins were both infants and weanlings in this study; 8 were both weanlings and juveniles; and 4 of these were infants, weanlings, and juveniles during the 2-year time frame of the study.

Design and Procedure

A pilot study was conducted from October 1993 to May 1994 to develop the ethogram and method for collection data (see Lehner, 1979, and P. Martin & Bateson, 1986, for related sampling procedures). All ethogram events ($N_{\text{events}} = 70$) were social, defined as exchange between two capuchins within an arm's length distance (AL) of each other, with the addition of nonsocial autonomic arousal indicators like scratching. Behaviors used in this analysis include (a) *approach*, when a capuchin moved within an AL of another capuchin without further interaction; (b) *outcome*, interactions less than 15-s long between capuchins within an AL, either initiated (overture) or received (response) by the focal animal; (c) *durations*, seconds collected for contact sitting, grooming self, grooming other, nursing, and playing bouts more than 15 s long; and (d) *autonomic arousal events*, including scratching, tail shivering, body shaking, and yawning. *Body shaking* was defined as a full body shiver. *Tail shivering* involved a rapid, small-amplitude shutter of the (sometimes piloerect) tail in any position. See Maestripieri, Schino, Aureli, and Troisi (1992) for an explanation of how these behaviors indicate autonomic arousal. We combined data from the two groups, although there were too few capuchins per developmental stage to examine group differences statistically.

Observational data were collected from June 1994 to June 1996 during 2–4 observation hours several times weekly by Ann Weaver only, therefore no interobserver reliability tests were run. Each youngster (but only youngsters) served as a focal animal (Altmann, 1974). A baseline focal animal sample lasted 20 min, during which all-occurrence recording was used to record social behavior initiated and received by the focal monkey in the dyadic format initiator-behavior-recipient. Conflict and postconflict focal animal samples followed the baseline sample format but began when the focal animal was the recipient of aggression or showed clear distress of more than 15 s duration during social interaction. Postconflict samples lasted 5 min and documented all of the social interactions that involved the focal capuchin.

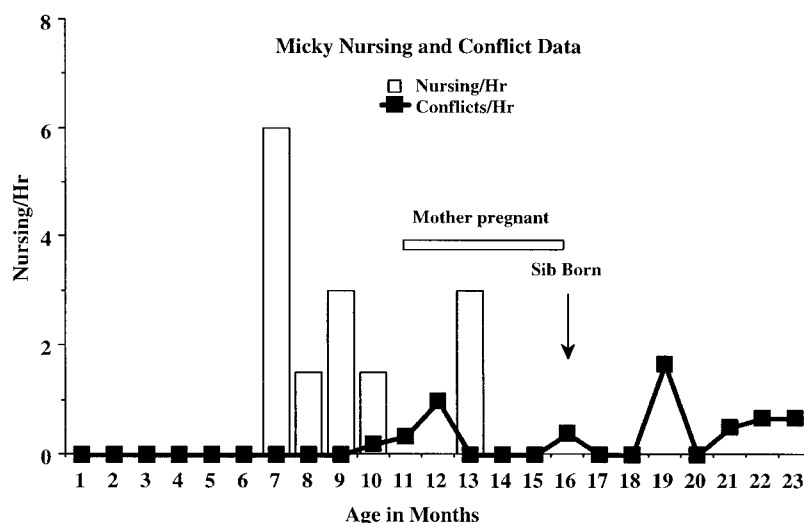


Figure 1. Changes in nursing rates over development. Sib = sibling.

During observations, the first author, Ann Weaver (AW), sat at a small table about 6.0 ft (1.8 m) away from the front of each enclosure. The capuchins were all captive born and were habituated to humans, but because capuchins are an active and responsive species, observations began after 5–10 min when they no longer paid attention to the observer. Observational data were typed into a laptop computer in real time in a form that could be analyzed with UNIX software and downloaded after each session for later analysis. A total of 774 20-min baseline focal animal samples and 591 conflict samples were collected. Observations involved at least 6 hr per month on each capuchin over the 24 months of the study.

Data on infants, weanlings, and juveniles were analyzed separately by developmental stage. The behavior of each focal monkey was analyzed separately by (a) individual social partners or (b) social partner class (mother, unrelated adults, and peers). Approaches, outcomes, and arousal events were rendered into hourly rates; we corrected for differing numbers of available partners in social partner classes with the following formula: total frequency of a behavior divided by total number of social partners per class divided by observation hours on the focal capuchin. Each focal capuchin's duration data were analyzed as mean bout length in seconds on the basis of all the bouts that were recorded while that focal monkey was in a given developmental stage.

We used nonparametric statistics (Siegel & Castellan, 1988) with a significance level of $p < .05$ because we (a) couldn't be sure that observational data were normally distributed and (b) considered nonparametric statistics to be more conservative (based on the ranks of the data rather than the actual data points) in dealing with obvious confounds, such as the pseudoreplication problem inherent in any developmental study in which the same youngsters are sampled longitudinally but are too few in number to be analyzed separately as repeated measures. Tests were one-tailed tests unless stated otherwise because we tested specific predictions drawn from attachment theory. Matched samples were evaluated with Wilcoxon signed-ranks tests ($T^+ =$ total plus ranks). Capuchins born during the study did not contribute equally to sequential time blocks; unmatched samples were evaluated with Mann-Whitney U tests. Behavior across the three developmental stages was compared with Kruskal-Wallis (KW) analyses of variance (ANOVAs).

Establishing the Existence of Attachment in Capuchins

According to Bowlby (1969), a species shows attachment if a youngster displays preferential and differential treatment toward its mother when it is calm and when it is aroused. The hypothesis that calm capuchin youngsters showed this behavior was tested by comparing youngsters' hourly rates of baseline approaches and overtures to their mothers with their hourly rates of baseline approaches and overtures to unrelated adult females and adult males. The expectation was that youngsters approached and interacted with their mothers more than they did with unrelated adults.

Arousal was defined as a youngster's behavior following conflict between itself and unrelated adults, that is, a capuchin other than its mother, a conflict subset that provided more youngsters ($n = 23$) for analysis than youngster-mother conflicts or youngster-peer conflicts. The hypothesis that aroused capuchin youngsters showed preferential and differential treatment toward their mothers was then tested by determining if they were significantly more likely to interact with their mothers in the 5-min post-conflict period, that is, showed selective attraction to her. Selective attraction is tested with the Corrected Conciliatory Tendency, or CCT, formula (Veenema, Das, & Aureli, 1994) by comparing the latency to an MO pair's first contact following the youngster's fight with an unrelated adult (post-conflict latency) with the latency to their first contact under baseline, nonconflict conditions. For baseline behavior, we used the first 5 min of the youngster's most recent baseline focal animal sample before the fight (matched control latency).

MO pairs whose postconflict latency to contact was shorter than their matched control latency were attracted pairs (a). MO pairs whose postcon-

flict latency to contact was longer than their matched control latency were dispersed pairs (d). MO pairs that either had the same postconflict and matched control latency to contact or did not make contact in either sample were neutral pairs (n). The CCT formula is $(a - d)/(a + d + n)$. Selective attraction occurred when a significantly higher proportion of MO pairs were attracted pairs than dispersed pairs according to a Wilcoxon signed-ranks comparison.

Qualitative Assessment of Attachment Security

The qualitative assessment of capuchin MO relationships as secure, resistant, or avoidant involved 5 steps.

Step 1. We perused the human attachment literature to identify all children's at-home behavior significantly associated with their Strange Situation behavior and type of attachment (e.g., Ainsworth et al., 1978). From this, we compiled detailed descriptions of baseline social behavior indicative of secure, resistant, and avoidant attachments in the form "if a relationship showed X, or more X than Y but no Z, then label it insecure," and so forth, to avoid the potential confound of having the same person collect the data and conduct the qualitative assessment of attachment security.

Step 2. We used the detailed descriptions as a guide to identify analogous MO behaviors among capuchin monkeys and labeled the resultant analogs *composite behaviors* to distinguish them from ethogram events, because they differed in several ways and were not redundant. Composite behaviors were themes of behavior that matched themes of human children at-home behavior and attachment security. Ethogram events were simple units of activity. Composite behaviors were based on the organizational perspective of attachment analysis and involved evaluating the purpose that the composite behavior appeared to serve (see Waters, 1978, for a demonstration of how the organizational perspective captures the attachment concept empirically). Ethogram events were documented as frequencies at face value.

Step 3. We evaluated each MO pair on each composite behavior with the outlier principle. The outlier principle quantitatively identified each pair's most and least frequent social behaviors compared with the average rate or duration of that behavior among MO pairs in that developmental stage. For each composite behavior separately, we calculated the mean and standard deviation of the behavior by all members in each developmental stage, derived the bell curve, and then looked where each MO pair's behavior was on it. High outliers were MO pairs whose behavior was +1 standard deviation of the mean. Low outliers were pairs whose behavior was -1 standard deviation of the mean. Remaining pairs were in the average range and neutral on that composite behavior.

For example, mother-infant pairs showed a mean of 0.35 and a standard deviation of 0.10 on the composite behavior Percent Contact Sit (Table C1, Weaver, 1999, p. 283). All pairs whose Percent Contact Sit scores were above 0.45 ($0.35 + 0.10$) were high outliers on this behavior. Their relationship was characterized as those that sat together more than the average mother-infant pair. Infants whose Percent Contact Sit scores were below 0.25 ($0.35 - 0.10$) were low outliers. Their relationships were characterized as those that sat together less than the average mother-infant pair.

Step 4. Each MO pair's status on all composite behaviors as high outliers, low outliers, or neutral were compiled into a detailed relationship profile.

Step 5. Each MO pair's relationship profile was compared with detailed descriptions of human children at-home behavior and interpreted as most similar to secure, resistant, or avoidant attachments. Ann Weaver completed this step so interobserver reliability tests were not run. Because insecurely attached children's at-home behavior correlated more highly with their Strange Situation behavior (Ainsworth et al., 1978), we looked for evidence of resistant and avoidant characteristics in capuchin MO relationships. Remaining relationships were labeled *secure*. Before cate-

gorizing relationships as secure, resistant, or avoidant, however, we compared mean composite behaviors across infancy, weaning, and juvenescence with Kruskal-Wallis one-way ANOVAs to distinguish between maturational effects and the effects of MO relationship quality.

Empirical Evaluation of MO Relationship Quality (MORQ)

A second, quantitative measure was then derived for each MO pair called the MORQ Index. The MORQ formula is as follows: relative affiliation rate divided by relative agonism rate. Affiliation was the combined hourly rate of mother grooming youngster and youngster grooming mother. Agonism was the combined hourly rate of four events (low-level threats, protest begging, avoidance, and distress without cause) that mother and youngster aimed at each other. A *low-level threat* was a minor menacing gesture aimed at a conspecific that gave a neutral response in return. *Protest begging* was a warbling vocalization given while eyebrow raising or staring at the social partner. *Avoidance* was an increase in interanimal distance by one capuchin moving away or leaning away. *Distress without cause* was a brief (less than 15 s) high-pitched screeching for no observable reason.

Relative measures were derived by, within each developmental stage separately, dividing each capuchin’s hourly rate by the mean rate of all capuchins in the same developmental stage. This produced a rate for each MO pair that was either high or low of the mean rate for pairs in that stage on that behavior. A MORQ Index was calculated for each MO pair per developmental stage.

We tested for an effect of developmental stage on MORQ values with a Kruskal-Wallis ANOVA. We tested for an effect of maternal dominance rank on MORQ by assigning each mother a numeric rank on the basis of her position in her colony’s dominance hierarchy (1 = *most subordinate*, 7 = *most dominant*) and deriving a Spearman rank-order correlation coefficient of the MORQ Index social rank ratio for all the pairs per developmental stage. Dominance data were drawn from laboratory records of supplants during 5-min samples of the capuchins’ general behavior drawn weekly for other purposes.

Comparison of Attachment and MORQ

We predicted that the qualitative assessment of relationships and their empirical MORQ values measured similar aspects of relationship quality. To test this, we derived the mean MORQ values of secure, resistant, and avoidant pairs and compared them for significant differences with a Kruskal-Wallis ANOVA. The prediction was that mean MORQ values would be higher among secure than among resistant and avoidant relationships.

Nature of Capuchin MO Relationships

We characterized the nature of secure and resistant relationships by comparing their mean values on composite behaviors and ethogram events with Mann-Whitney *U* tests. We did not explore the nature of avoidant relationships for two reasons. First, there were only four avoidant relationships. Only data with a minimum of 5 data points (e.g., 5 capuchins, five samples, five bouts, etc.) were analyzed in this research in keeping with similar restrictions in statistical tests (e.g., chi-square; Siegel & Castellan, 1988). Second, the behavior of avoidant youngsters was often opposite to that of resistant youngsters (Weaver, 1999) and therefore was not combined with it to avoid diluting the behavioral effects we were looking for.

For the composite behaviors of complexity and responsiveness, we identified correlated ethogram events with Spearman rank-order correlation coefficients. For the composite behavior of balance, we tested the prediction that secure MO pairs had greater symmetry in interaction than resistant MO pairs by classifying each relationship (per developmental stage) above the median as highly balanced and those below the median as less balanced and comparing the number of MO pairs per cell with a chi-square goodness of fit.

Results

Establishing the Existence of Attachment

Table 1 shows that calm capuchin youngsters showed preferential and differential treatment of their mothers compared with

Table 1
Hourly Rates of General Social Interaction From Brown Capuchin Youngsters to Adult Social Partners

Developmental stage	Mother		Adult females			Adult males		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	T ⁺	<i>M</i>	<i>SD</i>	T ⁺
Infancy								
Approaches ^a	2.44	1.16	1.55	0.77	78*	1.50	0.88	78*
Overtures ^b	6.92	2.85	1.53	0.76	78*	3.30	1.33	72*
Responsiveness ^c	3.16	2.67	0.58	0.31	73*	0.39	0.25	76*
Weaning								
Approaches ^a	3.68	2.42	1.59	0.97	53*	2.61	1.15	43
Overtures ^b	7.82	2.48	2.49	2.28	55*	4.33	1.89	45*
Responsiveness ^c	1.54	1.23	0.67	0.28	49*	1.03	0.41	40
Juvenescence								
Approaches ^a	3.65	1.58	1.17	0.79	132*	1.74	0.90	129*
Overtures ^b	6.39	3.66	1.60	1.13	132*	2.91	2.29	122*
Responsiveness ^c	0.91	0.83	0.62	0.52	98*	0.93	0.53	61

Note. T⁺ = total plus ranks.

^a Approaches achieved arm’s length proximity without further interaction. ^b Overtures were social events less than 15 s initiated by youngster capuchins. ^c Responsiveness is the rate at which youngster capuchins gave a clear response (social events less than 15 s) to an overture by a social partner, corrected for others’ rates of social initiative.

* *p* < .05.

unrelated adult females in all respects and adult males in most respects (youngsters behavior toward their fathers was not tested because their identities were unknown). The hypothesis that aroused capuchin youngsters showed preferential and differential treatment toward their mothers was also supported. Youngsters showed selective attraction to their mothers by behaving as attracted pairs following 81% of the youngster–unrelated-adult conflicts ($T^+ = 169$, $z = 2.67$, $p = .02$, $N = 23$).

Qualitative Assessment of Attachment Security

The detailed descriptions of human children at-home behavior associated with secure, resistant, and avoidant attachments are presented in Appendix A. Table 2 lists the 18 composite behaviors from capuchin focal animal samples that were deemed analogous to human children's at-home behavior. Five behaviors showed maturational effects by decreasing significantly as youngsters aged

(percent contact sit, contact sit bout length, maternal grooming, complexity, and maternal responsiveness). Appendix B gives three samples of relationship profiles derived from our analysis with the outlier principle. Table 3 shows that the only type of attachment that was absent among capuchin relationships was the avoidant weanling.

Empirical Evaluation of MORQ

MORQ values ranged from 0.15 to 5.00. The MORQ summarizes an MO pair's ratio of positive to negative interactions in their relationship, for example, the infant Lex had a low MORQ of 0.39 with his mother, Lulu, indicating their relationship had three times more agonism than affiliation. Lex's MORQ of 0.39 was derived from the ratio 0.47/1.19. The numerator 0.47 (the measure of affiliation in Lex's and Lulu's relationship relative to other capuchin mother–infant pairs) showed they were about half as affilia-

Table 2
Brown Capuchin Composite Behaviors Used to Evaluate Attachment Security

Composite behavior	Description
% contact sit	Percentage (duration) of total focal observation time the MO pair spent in contact; typifies nature of the pair's interaction style.
Mean contact sit bout length (in seconds)	Mean of all contact duration data to characterize average time a pair spent sitting together per interaction.
Absolute Z sit score ^a	Transformed standard deviation score of contact sit bout length to measure predictability in interaction.
Maternal grooming	Hourly rate of a mother grooming her offspring during contact sitting.
% maternal grooming	Percentage of contact sit time that a mother groomed her offspring (duration data).
Initiative index ^b	Identified member of MO pair more responsible for starting interactions.
Interaction rate	Hourly rate of bouts of social exchanges from a mother to her youngster and a youngster to its mother separated by 30 s or more.
Complexity ^c	Mean number of social events per interaction to characterize the breadth of typical interactions.
Balance	Spearman rank-order correlation coefficient of 19 MO social events defined as approaches and outcomes on the ethogram (Weaver, 1999).
Youngster responsiveness	Proportion of received overtures from a mother to which her youngster gave a clear response. This measures youngsters' passivity in interaction.
Youngster avoidance	Hourly rate at which a youngster avoided its mother.
Youngster squabbling	Hourly rate of a youngster's low-level threats, protests, and distress without cause toward its mother that did not get a response from her.
Nervous milling	Hourly rate of all approaches to measure how often a youngster does laps around the group.
Autonomic arousal	Hourly rates of autonomic arousal indicators, that is, scratching, body shivering, tail shaking, and body shivering.
Maternal responsiveness	Proportion of received-social overtures from a youngster to which its mother gave a clear response.
Maternal avoidance	Hourly rate of a mother's avoidance of her youngster.
Maternal squabbling	Hourly rate of a mother's low-level threats, protests, and distress without cause toward her youngster that did not get a response from the youngster.
Maternal response latency	A mother's response time to her youngster's overtures in real time (in seconds).

Note. MO = mother–offspring.

^a Transformed standard deviation score of contact sit bout length with the Tufts–Forsythe test | youngster's score—Median | (Keppel, 1991, p. 102). ^b Calculated as (youngster minus mother)/(youngster + mother) on the number of times youngsters or their mothers started interactions; the closer the index is to + 1.0, the greater the youngster's responsibility for starting interactions with its mother. Scores within .33 of 0 constitute the middle portion and are deemed those representing the greatest balance in initiative. ^c Pairs with low complexity typically exchanged few behaviors, for example, a complexity of 3.0 = approach, sit, and groom; pairs with high complexity exchanged a range of behaviors, for example, approach, sit, groom, invite attention, nurse, avoid, scold, and then sit nearby.

tive as the average mother–infant pair in the study. The denominator 1.19 showed they exchanged over twice as much agonism as the average mother–infant pair in the study. As a mother–infant pair, Lulu and Lex showed less affiliation and more agonism toward each other than other mother–infant pairs and exemplified an insecure capuchin MO relationship.

MORQ values did not vary with developmental stage (KW = 0.58, df = 2, ns, N = 38) or maternal rank (infancy, $r_s = -.28$; weaning, $r_s = -.09$; juvenescence, $r_s = -.02$). Infant and juvenile indices were positively skewed (i.e., the mean was higher than the median; infancy range = 0.39–3.54; juvenescence range = 0.00–4.42) and had Pearson’s coefficients of skew (sk) of 0.93 and 0.86, respectively. Weanling indices were normally distributed (range = 0.15–5.00, sk = 0.42).

Of the 14 capuchins that contributed data in sequential developmental stages, 5 changed their MORQ Index, all from secure to insecure. Four of the changes occurred at the onset of their mother’s next pregnancy. The mother of the remaining capuchin was concurrently involved with changing her social rank.

Comparison of Attachment and MORQ

The qualitative and empirical assessment of MO capuchin relationships measured similar aspects of relationship quality. Figure 2 shows that MO pairs that had been qualitatively assessed with secure relationships had significantly higher MORQ Index values than MO pairs that had been qualitatively assessed with insecure relationships (KW = 13.30, df = 2, $p = .01$, N = 38; $M \pm SD$ MORQ_{Secure} = 2.17 ± 0.30, N = 22; MORQ_{Resistant} = 0.80 ± 0.15, N = 12; MORQ_{Avoidant} = 0.63 ± 0.23, N = 4). We applied heuristic labels as follows. Youngsters whose MORQ values were above the median in their developmental stage were labeled *secure*. Youngsters whose MORQ values were below the median were labeled *insecure*. For subsequent analyses, the term *insecure* refers only to resistant youngsters; avoidant data were excluded for reasons given under the Method section.

Composite Behaviors

The comparison of secure and resistant MO relationships in Table 4 shows that resistant MO pairs scored higher on every composite behavior in which they differed significantly from secure pairs. Ethogram events that correlated with the composite behavior *complexity* depended on attachment security. Complexity correlated positively with rates of maternal grooming ($r_s = .88$, N = 22) among secure pairs but correlated positively with rates of

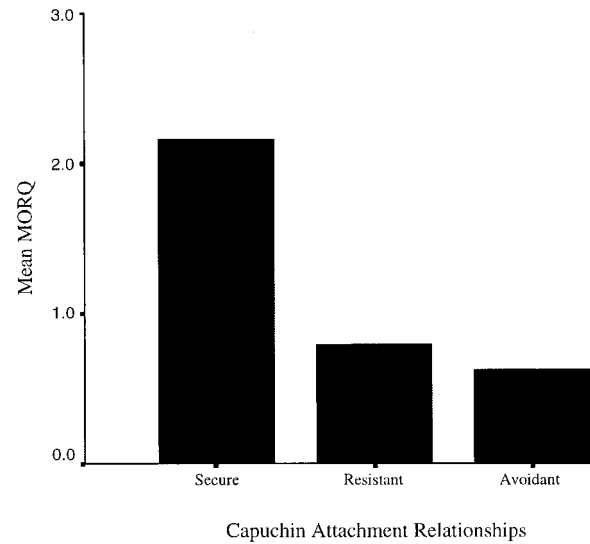


Figure 2. Empirical mother–offspring relationship quality (MORQ) values ($M \pm SE$) and quantitative attachment classifications in brown capuchin MO pairs.

youngsters avoiding their mother ($r_s = .75$, N = 12) and mothers squabbling at their youngsters ($r_s = .77$) among resistant pairs.

The composite behavior *youngster responsiveness to maternal overtures* showed that youngsters in resistant MO pairs (N = 12) were significantly likely to respond when their mothers were bunny sitting toward them (see Figure 3, $r_s = .72$), when their mothers showed interest in infant behavior¹ toward them ($r_s = .48$) and when she groomed them ($r_s = .47$) but were unlikely to respond when their mothers aimed low-level aggression at them ($r_s = -.61$) or sat at AL from them ($r_s = -.42$). Ethogram events that correlated with responsiveness (behavior that resistant youngsters responded to their mother’s overtures with) included oral–genital contact ($r_s = .48$), interest-in-infant behavior ($r_s = .50$), and suckling ($r_s = .43$). Resistant youngsters showed more nervous milling than did secure youngsters throughout development (infants: $U = 4$, $p = .05$, $N_sN_1 = 5$, 5; weanlings: $U = 0$, $p < .05$, $N_sN_1 = 6$, 4; juveniles: $U = 5$, $p = .05$, $N_sN_1 = 11$, 3).

Secure youngsters (n = 22) were significantly likely to respond to their mothers when she sat in direct contact with them ($r_s = .50$), invited their attention ($r_s = .55$), sat at AL from them ($r_s = .50$), and avoided them ($r_s = .60$). The behavior they responded with included showing food interest in her food ($r_s = .57$), grooming her ($r_s = .57$), suckling her ($r_s = .37$), and sitting at AL from her ($r_s = .47$). Analysis of the composite behavior balance revealed that secure youngsters showed greater symmetry in interaction with their mothers than resistant youngsters did, $\chi^2(1, N = 38) = 6.76$, $p = .01$.

¹ Interest-in-infant behavior is a ritualized brown capuchin gesture involving repetitive head tilting and lipsmacking while bringing the face close to the face of a conspecific that is the aim of the interest. It is typically reserved for altricial infants. However, older capuchins use the interest-in-infant gesture in other contexts, for example, in apology, in soliciting attention, or during requests for nipple access.

Table 3
Distribution of Brown Capuchin Attachment Security Categories

Attachment security	Infants	Weanlings	Juveniles	Total
Avoidant	2		2	4
Secure	5	6	11	22
Resistant	5	4	3	12
Total	12	10	16	38

Note. Of the 38 mother–offspring pairs total in different developmental stages, 14 pairs contributed sequential developmental data (6 infants–weanlings, 8 weanlings–juveniles, 4 infants–weanlings–juveniles) during the 2-year time frame of the study.

Table 4
Mean Composite Behaviors Across Mother–Offspring Brown Capuchin Pairs With Different Attachment Security Classifications

Composite behaviors ^a	Secure	Insecure	<i>U</i> ^b
% contact sit	0.16	0.30	63.0**
Contact sit bout length	191.55	164.79	99.0
Absolute Z sit score	58.30	106.34	97.5
Maternal grooming	1.49	1.88	10.0
% maternal grooming	0.24	0.22	124.5
Initiative index	0.31	0.29	129.0
Interactions hourly rate	7.35	10.29	72.5**
Complexity	12.93	19.99	60.0**
Youngster responsiveness	0.28	0.56	60.5**
Youngster avoidance of mother	0.30	0.63	83.5*
Youngster squabbling at mother	0.19	1.25	24.0**
Youngster nervous milling	30.02	36.96	75.0**
Youngster arousal	17.01	16.97	170.0
Maternal responsiveness	0.31	0.33	116.0
Maternal avoidance of youngster	0.42	0.61	83.5*
Maternal squabble at youngster	0.13	0.82	20.0**
Maternal latency to respond	36.77	42.60	128.0

^a Data are mean composite behaviors defined in Table 2. ^b Mann–Whitney *U* tests ($N_S N_I = 22, 12$).

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

Ethogram Events

Table 5 shows that resistant MO pairs had higher frequencies than secure pairs on every significantly different ethogram event. Differences were primarily associated with youngsters' overtures to their mothers.

Table 5
Social Behavior That Distinguished Secure and Insecure Mother–Offspring Brown Capuchin Pairs

Behavior ^a	Secure		Insecure		<i>U</i> ^b
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Youngster's social overtures to mother					
Bunny sit (J) ^c	0.04	0.08	0.40	0.30	0.0*
Contact sit (J)	2.58	1.35	5.36	0.65	1.0*
Sit at arm's length	1.32	0.83	2.02	0.93	73.5**
Spread-leg display (J) ^d	0.03	0.04	0.65	0.73	0.0*
Neutral approach (J)	3.52	1.46	5.15	1.88	8.0*
Youngster's social responses to mother					
Invite attention	0.19	0.20	0.40	0.38	75.0**
Mother's social overtures to youngster					
Cautious approaches	0.09	0.12	0.26	0.28	84.5*
Cautious approaches (I)	0.08	0.11	0.39	0.30	3.5*
Cautious approaches (W)	0.08	0.10	0.23	0.31	7.5
Neutral approaches (J)	1.74	0.66	4.08	1.77	1.0***
Mother's social responses to youngster					
Oral–genital contact (J)	0.00	0.00	0.27	0.41	5.5 ^e

Note. Behavioral differences were significantly different across all developmental stage ($N_S N_I = 22, 12$) or within individual developmental stage. Within-developmental stage differences are indicated by parenthetical abbreviations for each stage. I = infancy, $N_S N_R = 5, 5$; W = weaning, $N_S N_R = 6, 4$; J = juvenescence, $N_S N_R = 11, 3$. Developmental trends are indicated by sequential stages.

^a Data are mean and standard deviation hourly rates of baseline ethogram events. ^b Mann–Whitney *U* tests. ^c See Figure 3. ^d See Figure 4. ^e $.05 < p < .10$.

* $p < .05$. ** $p < .01$. *** $p < .0001$.

Discussion

The most important finding of this research is that the MORQ Index provides an objective, continuous measure of attachment security that revealed extensive differences in secure and insecure capuchin MO relationships without requiring mothers and youngsters to be separated. The MORQ Index characterizes a relationship by its proportion of affiliation to agonism rather than by reflecting differences in either affiliation or agonism. The Index numerically represents the most familiar aspects of physical contact in capuchin MO relationships, that is, whether the typical interaction is more friendly or more stressful. It fulfills the criteria that a relationship measure be objective, continuous, based on a few ethologically meaningful but opposite behaviors, and reflective of both partners' contributions to their relationship.

The MORQ also provides the basis of each relationship's probable role in either reducing or increasing a youngster's tensionful affective arousal during development. Conceptually, we interpret conflict and agonism in an intact MO relationship as a naturally occurring, ecologically valid form of separation because social partners do not have access to each other until reconciliation or reunion, similar to social partners that have been separated during laboratory procedures or for other reasons. Insecure capuchin youngsters in this study were defined as those with higher proportions of agonism in their maternal relationships. They were also the class of youngsters that showed the most nervous milling (this study) and significantly lower thresholds for expressing negative arousal (Weaver & de Waal, 2002). Given that youngsters that have experienced regular separations exaggerate negative arousal (Boccia et al., 1991) and become emotionally disorganized (Clarke et al., 1998) when stressed, the greater behavioral arousal among

insecure youngsters in this study may stem from their greater experience with maternal unavailability and/or unpredictability during formative development.

Human children in secure and insecure MO relationships differ in their responses to physical contact commensurate with their positive or negative experience with it in their MO relationships, respectively (Ainsworth et al., 1978). In primates, physical contact occurs along a continuum between affiliative or positive interactions, as in grooming, and negative interactions, as in aggression. In a number of nonhuman primate species, grooming reveals the network of social attachments in a group (Sade, 1965), provides comfort, and relieves tension (Boccia, 1989), so it was an obvious candidate for measuring affiliation in relationships.

Grooming was particularly pertinent to capuchin relationships, which are highly intimate and structured (Fragaszy, Baer, & Adams-Curtis, 1991), because it is a socially intimate behavior involving physical contact but that is unrelated to direct infant care. Grooming is the most reliable indication of affiliation among capuchins (Welker, Höhmann-Kröger, & Doyle, 1992), especially in MO pairs (Welker, Becker, Höhmann, & Schäfer-Witt, 1990). In the current study, approaches were easy to identify as aggressive or ambivalent but were difficult to operationalize as friendly so our neutral approaches (Weaver, 1999) did not suffice for affiliation, and in any case increase as youngsters age (Welker et al., 1990). Proximity was also not a candidate for affiliation because some (unidentifiable) proportion of its occurrence was an emotionally

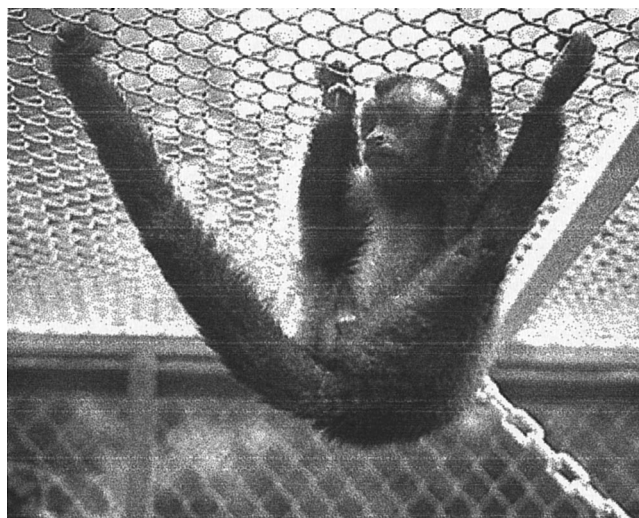


Figure 4. Spread-leg gesture in brown capuchins.

neutral consequence of available space in a cage. Finally, although contact sitting among capuchins was often affiliative in nature, it also often occurred under tense circumstances as well, for example, during temper tantrums (Weaver & de Waal, 2002), so the hourly rates of contact sitting did not suffice as affiliation either. An important caveat is that the use of grooming as an indication of affiliation in a relationship does not imply that the grooming individuals automatically share emotional attachments.

Tensions and conflicts between mothers and youngsters have long-term effects on infant behavior (Simpson & Simpson, 1986), so it was important to define capuchin agonism fully. We felt justified in combining low-level threats, protest begging, avoidance, and distress without cause as agonism in the denominator of the MORQ because all were typical expressions of tension in capuchin relationships (Fragaszy, Baer, & Adams-Curtis, 1994; Welker et al., 1990), not just among MO pairs.

Clarke and Boinski (1995) demonstrated that nonhuman primate species differ on disposition and temperament, some reactive and others more quiescent. These differences need to be taken into account when using nonhuman primates as models for human social behavior. One advantage of the MORQ Index is that it takes species dispositions into account by using the concepts of agonism or affiliation to evaluate relationships in terms of species-typical behaviors. A behavioral representative of affiliation that is appropriate for one species may not be appropriate for another. For example, although grooming was deemed the most appropriate representative of affiliation in a capuchin relationship, it may not be as reliable or valid an indication of affiliation as proximity among patas monkeys (*Erythrocebus patas*), genital-genital rubbing among female bonobos (*Pan paniscus*), or cradling among howler monkeys (*Alouatta palliata*).

The MORQ may also apply to a range of observational methods. For example, capuchins in this study primarily showed affiliation through grooming and tensions through the agonistic behaviors included in the Index. In contrast, a well-established ethogram of bonnet macaque (*Macaca radiata*) and pigtail macaque (*M. nemestrina*) behavior (Laudenslager et al., 1995) provided a different



Figure 3. Bunny sitting in brown capuchins.

set of affiliative and agonistic behaviors that were used to derive MORQ indices on 30 macaques (Weaver, Richardson, & Laudenslager, 2002). On the macaque ethogram, grooming had been imbedded under the broader rubric of touch, so the macaque MORQ Index used touch instead of grooming as the measure of affiliation. Agonistic macaque events (aggression, submission, and denial of the nipple) differed from agonistic events exchanged among capuchins but were valid and reliable expressions of agonism among the macaques. Preliminary comparisons indicate that secure and insecure macaque MO relationships differ significantly in response to a social challenge.

In the current study, a comparison of the behavior of youngsters with high MORQ values and secure relationships with the behavior of youngsters with low MORQ values and insecure relationships revealed that the two kinds of youngsters experienced very different types of maternal relationships. These data may provide an initial accounting of sources of the variability that so notably characterizes capuchin social behavior (Fragaszy, Visalberghi, & Robinson, 1990). Insecure youngsters were initially distinguished from secure youngsters by high proportions of agonism compared with affiliation in their MO relationships. During interactions with their mothers, insecure youngsters experienced nearly 10 times more agonism as secure youngsters. Insecure youngsters avoided their mothers over twice as often as secure youngsters avoided their mothers and squabbled at her seven times more often than secure capuchins squabbled at their mothers. It is not clear which came first, maternal agonism or youngster agitation, but mothers in insecure pairs avoided their youngsters and squabbled at them over six times more than mothers in secure pairs avoided and squabbled at their youngsters.

However, insecure pairs were not wholly agonistic and their baseline interactions included affiliative behavior. Mothers of insecurely attached capuchins groomed their offspring at rates that did not differ from mothers of securely attached capuchins, and when they behaved affiliatively to their youngsters, the youngsters were conspicuously responsive with strongly affiliative attachment behaviors. The nature of their responsiveness was reminiscent of the heightened sensitivity and responsiveness that abused human children show toward the adults that abuse them (H. P. Martin, 1976).

Nevertheless, affiliation in insecure pairs was eclipsed by unpredictability. Because unpredictability evokes greater pituitary-adrenal activation than does physical abuse (Coe et al., 1985), this unpredictability suggests that insecure capuchin relationships were extremely tense. The data support this interpretation, revealing that insecure relationships regularly included approach-avoidance fluctuations. First, approach-avoidance was suggested by the patterning of their interactions. Insecure pairs spent significantly more time sitting in contact but also had higher rates of contact sitting and sitting at AL. To have higher rates, insecure pairs must also have had higher rates of departures (not documented in this study). These data insinuate that members of insecure pairs were restless in interaction and frequently broke contact. A further insinuation of restlessness was that insecure pairs were twice as inconsistent as secure pairs in their predictability of sitting behavior (absolute Z sit scores, see Tables 2 and 4).

Second, approach-avoidance was suggested by evidence of asynchrony during social interaction. While sitting together, members of insecure pairs were significantly less predictable to their

partners, using one set of behaviors when starting interactions and another set when responding. They also mirrored each other's social events less, that is, were less balanced.

In addition, the ambiguity in several of the behaviors that insecure pairs typically used in interaction suggested they spent more time trying to get interaction started versus actually interacting. For example, several of the behaviors on Table 5 had alternative social functions. Brown capuchins use the ethogram event *invite attention* as a sign of friendly intention, as a slightly threatening gesture, and as a cautious attempt to interact with a partner whose intentions are unclear. Though occurring in different contexts, the result for data collection was the same behavior—an invitation to interact. The same is true for oral-genital contact. Oral-genital contact was prominent from mother to youngster among insecure pairs but used in both affiliative and distressed contexts. This was also true for the stereotyped interest-in-infant behavior, bunny sitting (see Figure 3), and suckling attempts (defined as high rates but low durations), although the spread-leg gesture (see Figure 4) was strictly submissive in function. Insecure pairs even showed ambivalence about contact with their frequent rates of cautious and neutral passes, which means they often simply hovered in each other's vicinity without interacting. Finally, tension was obviously high from both the elevated levels of agonism in low MORQ values and in higher rates of nervous milling among insecure youngsters compared with secure youngsters in all stages of development.

This evidence of extensive approach-avoidance behavior argues that insecure capuchin relationships were basically ambivalent or capricious. In this respect, insecure capuchin relationships closely resemble resistant attachments in human MO relationships (Ainsworth et al., 1978).

In strong contrast, secure pairs showed, in our opinion, the quintessence of relationship quality: the ability to sit together quietly. Capuchin monkeys are a highly active species and particularly likely to display contentment or intimacy (Fragaszy et al., 1991) by quiet physical contact. Further, secure pairs differed from insecure pairs by behavior that was noticeably absent from their relationships: strife and tension. Their relationships were characterized by highly positive physical contact and amiability founded on reliable maternal availability, predictability, and complementarity in interaction.

Because the attachment literature reports that securely attached human MO pairs share rich and complex interactions of some duration compared with insecure pairs, it was initially counterintuitive that secure capuchin pairs showed less complexity and time together than insecure pairs. However, capuchin interactional complexity is "dull" when it is affiliative because the capuchins spend long periods grooming and is "complex" when it is agonistic. This is another reminder of the importance of interpreting attachment behavior in terms of each species' individual dispositions (Clarke & Boinski, 1995).

A striking aspect of secure capuchins' relationships was that youngsters were responsive to their mothers' affiliativeness and to her agonism. Specifically, secure capuchins responded with affiliative behavior when their mothers avoided them (in contrast, insecure capuchins were primarily responsive to their mothers' affiliativeness). This behavior suggested secure capuchins were not intimidated by their mothers' agonistic acts. Notably, the amiable nature of their relationships did not change as youngsters

aged other than the normal waning of MO exclusivity (Fairbanks & McGuire, 1985; Nicolson, 1986).

In summary, few normative developmental data are available for mother-reared capuchins (Fragaszy et al., 1991), so MORQ values revealing two very different types of MO relationships make a substantial contribution to the database on capuchin development. Secure capuchin MO pairs had amiable relationships. They had a predictable style of highly positive physical contact during interaction and were characterized mainly by the absence of strife and tension in their relationships. Insecure capuchin MO pairs had capricious relationships. They had an unpredictable, approach-avoidance style of stressful physical contact during interaction and were characterized mainly by an enduring attraction eclipsed by frequent ambivalence and tension.²

To conclude, the MORQ Index is a simple, well defined empirical measure of MO relationship quality and attachment security that provides a theory-based way to divide individuals by the nature of their relationships and compare their behavior. Future research should include use of the MORQ to study how the nature of the intact MO relationship influences the development of the infant's social skills and emotional functioning.

² These detailed characterizations illustrate the difference between the Hinde Index (Hinde & Atkinson, 1970) and the MORQ Index. MORQ characterizes the relationship between the positive and negative aspects of social interaction whereas the Hinde Index characterizes a mother's and an infant's relative contributions to the infant's developing independence. The Hinde Index can identically characterize two distinct relationships, for example, one in which partners are in proximity 80% of the time versus one in which partners are in proximity 20% of the time, if mothers and infants contribute identically to the infant's independence. In contrast, the MORQ Index is less likely to characterize two distinct relationships identically.

References

- Ainsworth, M. D. S., Bell, S. M., & Stayton, D. J. (1974). Infant-mother attachment and social development: Socialisation as a product of reciprocal responsiveness to signals. In M. P. M. Richards (Ed.), *The integration of a child into a social world* (pp. 99-135). Cambridge, England: Cambridge University Press.
- Ainsworth, M. D. S., Blehar, M., Waters, E., & Wall, S. (1978). *Patterns of attachment*. Hillsdale, NJ: Erlbaum.
- Ainsworth, M. D. S., & Wittig, B. A. (1969). Attachment and exploratory behavior on one year olds in a strange situation. In B. M. Foss (Ed.), *Determinants of infant behaviour* (Vol. 4, pp. 111-136). London: Methuen.
- Alberts, J. R., & Gubernick, D. J. (1990). Functional organization of dyadic and triadic parent-offspring systems. In N. A. Krasnegor & R. S. Bridges (Eds.), *Mammalian parenting* (pp. 416-440). New York: Oxford University Press.
- Altmann, J. (1974). Observational study of behaviour: Sampling methods. *Behaviour*, *49*, 227-267.
- Altmann, J. (1980). *Baboon mothers and infants*. Cambridge, MA: Harvard University Press.
- Berman, C. M. (1980). Mother-infant relationships among free-ranging rhesus monkeys on Cayo Santiago: A comparison with captive pairs. *Animal Behaviour*, *28*, 860-873.
- Bernstein, I. S., Judge, P. G., & Ruehlmann, T. E. (1993a). Kinship, association, and social relationships in rhesus monkeys (*Macaca mulatta*). *American Journal of Primatology*, *31*, 41-53.
- Bernstein, I. S., Judge, P. G., & Ruehlmann, T. E. (1993b). Sex differences in adolescent rhesus monkey (*Macaca mulatta*) behavior. *American Journal of Primatology*, *31*, 197-210.
- Boccia, M. L. (1989). Comparison of the physical characteristics of grooming in two species of macaques (*Macaca nemestrina* and *M. radiata*). *Journal of Comparative Psychology*, *103*, 177-183.
- Boccia, M. L., Reite, M., Kaemingk, K., Held, P., & Laudenslager, M. (1989). Behavioral and autonomic responses to peer separation in pigtail macaque monkey infants. *Development Psychobiology*, *22*, 447-461.
- Boccia, M. L., Reite, M., & Laudenslager, M. L. (1991). Early social environment may alter the development of attachment and social support: Two case reports. *Infant Behavior and Development*, *14*, 253-260.
- Bowlby, J. (1969). *Attachment and loss: Vol I. Attachment*. New York: Basic Books.
- Brazelton, T. B., Koslowski, B., & Main, M. (1974). The origins of reciprocity: The early mother-infant interaction. In M. Lewis & L. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 49-76). New York: Wiley.
- Caine, N. G., Earle, H., & Reite, M. (1983). Personality traits of adolescent pig-tailed monkeys (*Macaca nemestrina*): An analysis of social rank and early separation experience. *American Journal of Primatology*, *4*, 253-260.
- Capitanio, J. P., & Reite, M. (1984). The roles of early separation experience and prior familiarity in the social relations of pigtail macaques: A descriptive multivariate study. *Primates*, *25*, 475-484.
- Clarke, A. S. (1993). Social rearing effects on HPA axis activity over early development and in response to stress in young rhesus monkeys. *Development Psychobiology*, *26*, 433-447.
- Clarke, A. S., & Boinski, S. (1995). Temperament in non-human primates. *American Journal of Primatology*, *37*, 103-125.
- Clarke, A. S., Hedeker, D. R., Evert, M. H., Schmidt, D. E., McKinney, W. T., & Kraemer, G. W. (1996). Rearing experience and biogenic amine activity in infant rhesus monkeys. *Biological Psychiatry*, *40*, 338-352.
- Clarke, A. S., Kraemer, G. W., & Kupfer, D. J. (1998). Effects of rearing condition on HPA axis response to fluoxetine and desipramine treatment over repeated separations in young rhesus monkeys. *Psychiatry Research*, *79*, 91-104.
- Clarke, A. S., & Schneider, M. L. (1993). Prenatal stress has long-term effects on behavioral response to stress in juvenile rhesus monkeys. *Developmental Psychobiology*, *26*, 293-304.
- Coe, C. L., Weiner, S. G., Rosenberg, L. T., & Levine, S. (1985). Endocrine and immune responses to separation and maternal loss in nonhuman primates. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 163-197). San Diego, CA: Academic Press.
- Fairbanks, L. A. (1989). Vervet monkey grandmothers: Effects on mother-infant relations. *Behaviour*, *104*, 176-188.
- Fairbanks, L. A., & McGuire, M. T. (1985). Relationships of vervet mothers with sons and daughters from one through three years of age. *Animal Behaviour*, *33*, 40-50.
- Fairbanks, L. A., & McGuire, M. T. (1987). Mother-infant relationships in vervet monkeys: Response to new adult males. *International Journal of Primatology*, *8*, 351-366.
- Fairbanks, L. A., & McGuire, M. T. (1988). Long-term effects of early mothering behavior on responsiveness to the environment in vervet monkeys. *Developmental Psychobiology*, *21*, 711-724.
- Fairbanks, L. A., & McGuire, M. T. (1993). Maternal protectiveness and response to the unfamiliar in vervet monkeys. *American Journal of Primatology*, *30*, 119-129.
- Fragaszy, D. M., Baer, J., & Adams-Curtis, L. (1991). Behavioral development and maternal care in tufted capuchins (*Cebus apella*) and squirrel

- rel monkeys (*Saimiri sciureus*) from birth through seven months. *Developmental Psychobiology*, 24, 375–393.
- Fragaszy, D. M., Baer, J., & Adams-Curtis, L. (1994). Introduction and integration of strangers into captive groups of tufted capuchins (*Cebus apella*). *International Journal of Primatology*, 15, 399–420.
- Fragaszy, D. M., Visalberghi, E., & Robinson, J. G. (1990). Variability and adaptability in the genus *Cebus*. *Folia Primatologia*, 54, 114–118.
- Goodall, J. (1967). Mother–offspring relationships in free-ranging chimpanzees. In D. Morris (Ed.), *Primate ethology* (pp. 287–346). London: Weidenfeld & Nicolson.
- Harlow, H. F., & Harlow, M. K. (1965). The affectional systems. In A. M. Shrier, H. F. Harlow, & F. Stollnitz, (Eds.), *Behavior on nonhuman primates* (Vol. 2, pp. 287–334). New York: Academic Press.
- Hinde, R. A. (1969). Analyzing the roles of the partners in a behavioral interaction—mother–infant relations in rhesus macaques. *Annals of the New York Academy of Sciences*, 159, 651–667.
- Hinde, R. A. (1979). *Toward understanding relationships*. New York: Academic Press.
- Hinde, R. A., & Atkinson, S. (1970). Assessing the roles of social partners in maintaining mutual proximity, as exemplified by mother–infant relations in monkeys. *Animal Behaviour*, 18, 169–176.
- Hofer, M. A. (1987). Early social relationships: A psychobiologist's view. *Child Development*, 58, 633–647.
- Keppel, G. (1991). *Design and analysis* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.
- Kraemer, G. W. (1985). Effects of differences in early social experience on primate neurobiological-behavioral development. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 135–161). San Diego, CA: Academic Press.
- Kraemer, G. W. (1992). A psychobiological theory of attachment. *Behavioral and Brain Sciences*, 15, 493–541.
- Kraemer, G. W., Ebert, M. H., Schmidt, D. E., & McKinney, W. T. (1991). Strangers in a strange land: A psychobiological study of infant monkeys before and after separation from real or inanimate mothers. *Child Development*, 62, 548–566.
- Kummer, H. (1982). Social knowledge in free-ranging primates. In D. R. Griffin (Ed.), *Animal minds—human minds* (Life Sciences Research Report 21). Berlin, Germany: Springer-Verlag.
- Lamb, M. E., Thompson, R. A., Gardner, W., & Charnov, E. L. (1985). *Infant–mother attachment*. London: Erlbaum.
- Laudenslager, M. L., & Boccia, M. L. (1996). Some observations of psychosocial stressors, immunity, and individual differences in nonhuman primates. *American Journal of Primatology*, 39, 205–221.
- Laudenslager, M. L., Boccia, M. L., Berger, C. L., Gennaro-Ruggles, M. M., McFerran, B., & Reite, M. L. (1995). Total cortisol, free cortisol, and growth hormone associated with brief social separation experiences in young macaques. *Developmental Psychobiology*, 28, 199–212.
- Laudenslager, M. L., & Worlein, J. (1998). Behavior/immune relationships in non-human primates. In M. Schedlowski & U. Tewes (Eds.), *Psychoneuroimmunology*. New York: Kluwer Academic/Plenum Press.
- Lehner, P. N. (1979). *Handbook of ethological methods*. New York: Garland STPM Press.
- Lester, B. M., Hoffman, J., & Brazelton, T. B. (1985). The rhythmic structure of mother–infant interaction in term and preterm infants. *Child Development*, 56, 15–27.
- Maestripieri, D., Schino, G., Aureli, F., & Troisi, A. (1992). A modest proposal: Displacement activities as an indicator of emotions in primates. *Animal Behaviour*, 44, 967–979.
- Martin, H. P. (Ed.). (1976). *The abused child: A multidisciplinary approach to developmental issues and treatment*. Boston: Balinger.
- Martin, P., & Bateson, P. (1986). *Measuring behavior*. Cambridge, England: Cambridge University Press.
- Nicolson, N. A. (1986). Infants, mothers and other females. In B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, & T. T. Struhsaker (Eds.), *Primate societies* (pp. 330–342). Chicago: University of Chicago Press.
- Rosenblatt, J. S. (1994). Psychobiology of maternal behavior: Contribution to the clinical understanding of maternal behavior among humans. *Acta Paediatr Supplement*, 397, 3–8.
- Rosenblum, L. A., & Youngstein, K. P. (1974). Developmental changes in compensatory dyadic response in mother and infant monkeys. In M. Lewis & L. A. Rosenblum (Eds.), *The effect of the infant on its caregiver*. New York: Wiley.
- Sade, D. S. (1965). Some aspects of parent–offspring and sibling relations in a group of rhesus monkeys, with a discussion of grooming. *Physical Anthropology*, 23, 1–18.
- Schino, G., d'Amato, F. R., & Troisi, A. (1995). Mother–infant relationships in Japanese macaques: Sources of inter-individual variation. *Animal Behaviour*, 49, 151–158.
- Siegel, S., & Castellan, N. J. (1988). *Nonparametric statistics for the behavioral sciences*. New York, McGraw-Hill.
- Simpson, M. J. A., & Simpson, A. E. (1986). The emergence and maintenance of interdyad differences in the mother–infant relationships of rhesus macaques: A correlational study. *International Journal of Primatology*, 7, 379–399.
- Spangler, G., Schieche, M., Ilg, U., Maier, U., & Ackermann, C. (1994). Maternal sensitivity as an external organizer for biobehavioral regulation in infancy. *Developmental Psychobiology*, 27, 425–437.
- Sroufe, L. A., & Waters, E. (1977). Attachment as an organizational construct. *Child Development*, 48, 1184–1199.
- Stern, D. N. (1974). Mother and infant at play. In M. Lewis & L. A. Rosenblum (Eds.), *The effect of the infant on its caregiver*. New York: Wiley.
- Suomi, S. (1982). Abnormal behavior and primate models of psychopathology. In J. Fobes & J. King (Eds.), *Primate behavior*. New York: Academic Press.
- Timme, A. (1995). Sex differences in infant integration in a semifree-ranging group of Barbary macaques (*Macaca sylvanus*, 1758) at Salem, Germany. *American Journal of Primatology*, 37, 221–231.
- Veenema, H. C., Das, M., & Aureli, F. (1994). Methodological improvements for the study of reconciliation. *Behavioral Processes*, 31, 29–38.
- Waters, E. (1978). The reliability and stability of individual differences in infant–mother attachment. *Child Development* 49, 483–494.
- Weaver, A. (1999). *The role of attachment in the development of reconciliation*. Unpublished doctoral dissertation, Emory University, Atlanta, Georgia.
- Weaver, A., & de Waal, F. (2002). *The mother–offspring relationship as template in social development: Reconciliation in captive brown capuchins*. Manuscript submitted for publication.
- Weaver, A., & de Waal, F. (2002). *Tantrums and allonursing in brown capuchins (Cebus apella)*. Unpublished manuscript.
- Weaver, A., Richardson, R., & Laudenslager, M. (2002). *Mother–offspring relationship quality and response to social challenge in young bonnet (Macaca radiata) and pigtail (M. nemestrina) macaques*. Manuscript submitted for publication.
- Welker, C., Becker, P., Höhmann, H., & Schäfer-Witt, C. (1990). Social relations in groups of the black-capped capuchin (*Cebus apella*) in captivity. *Folia Primatologia*, 54, 16–33.
- Welker, C., Höhmann-Kröger, H., & Doyle, G. A. (1992). Social relations in groups of black-capped capuchin monkeys (*Cebus apella*) in captivity: Sibling relations from the second to the fifth year of life. *Z. Saugtierkunde*, 57, 269–274.

Appendix A

Qualitative Assessment of Attachment Security—Detailed Descriptions
of Human Children At-Home Behavior

Resistant Human MO Relationships

Resistant human MO relationships showed the following at-home or baseline behavior: A low-to-moderate level of youngster initiative at promoting social interaction with mother; a high variability in the amount and nature of maternal responsiveness to a youngster's overtures; a higher variability in youngster's responsiveness to maternal overtures; an inconsistency in the relative contributions mother and youngster each made to initiating and maintaining social interaction; a tendency for a youngster to show increased arousal during or following interaction with mother; an infrequency of physical contact and higher rates of anger, arousal, or general discomfort rather than positive or affiliative complexity during physical contact with mother; and higher rates of fragmented interactions with mother.

Avoidant Human MO Relationships

Avoidant human MO relationships showed the following at-home or baseline behavior: A tentative, low level of youngster initiative at promoting social interaction with mother; a low or agonistic maternal responsiveness to a youngster's overtures; a low level of youngster responsiveness to

maternal overtures; an inconsistency in the relative contributions mother and youngster each made to initiating and maintaining social interaction with the youngster; little complexity of interaction; short affiliative interactions; a low tendency for a youngster to show increased arousal during or following interaction with mother; moderate discomfort but lower arousal during physical contact with mother; shorter bouts of physical contact; and higher levels of anger.

Secure Human MO Relationships

Secure human MO relationships showed the following at-home or baseline behavior: A high level of youngster initiative at promoting social interaction with mother, a high level of maternal response to a youngster's overtures, a high level of positive youngster responsiveness to maternal overtures, a greater balance in the relative contributions mother and youngster each made to initiating and maintaining social interaction, a greater complexity of interaction, longer affiliative interactions, a low tendency for a youngster to show increased arousal during or following interaction with mother, and mild-to-moderate resistance during physical contact and little avoidance.

Appendix B

Relationship Profile Interpreted as Secure

Bravo (Infant)—Secure

Outlier behaviors. Bravo's infancy stood out as having low general maternal responsiveness, low maternal squabbling, and zero infant squabbling; he was high on maternal grooming duration. They had a balanced initiative index.

Relationship profile. This looked like a quiet but predictable, complete relationship. This pair did not interact often or sit together much compared with other mother–infant pairs (the lower half for interactions/hour—about once every 10 min—and of contact sitting). However, they contributed about equally to initiating interaction and typically sat together a predictable amount of time (the second lowest absolute Z score: 30 s). They were matched on responsiveness, each averaging clear responses to one fourth of the overtures they received from the other; this was very low maternal responsiveness compared with other mothers with infants. The low responsiveness score may be accounted for by the fact that Bravo's mother, Bias, was grooming Bravo a high proportion of the time (Bias had the highest maternal grooming durations score among infant pairs, 0.38; she was grooming him over one third of the time they sat together). Bias was also a tolerant mother: Bravo had the highest nursing hourly rate, averaged more than one nursing attempt per contact-sitting bout, and never squabbled at her. Bias also never squabbled at Bravo.

Sneech (Weanling)—Insecure Resistant

Outlier Behaviors

This pair's relationship was characterized by a low nursing bout length but high maternal grooming duration, maternal avoidance, youngster avoidance, youngster squabbling, and nervous milling. Their initiative index was not balanced but skewed toward the youngster Sneech.

Mother–Weanling Relationship Profile

Sneech had shown high levels of autonomic arousal as an infant but showed agitation in nervous milling as a weanling. Though technically moderate on contact sitting duration, this pair had the third lowest score, so they did not sit together much compared with other pairs. They were balanced in terms of responsiveness, although Sneech was somewhat higher. However, their responsiveness could well have been accounted for by the following negative expressions. Sneech had a very high avoidance rate, about three times as high as the mean for weanlings avoiding their mothers, and a very high squabbling rate, about four times higher than the weanling mean. His mother, Star, had the highest avoidance rate of any mother–weanling pair, clearly avoiding Sneech three times as often as the mean. Sneech was weaned very early, like Lex, reflected in one of the lowest hourly nursing rates and lowest average bout lengths of the weanlings. Sneech had one of the two highest weanling nervous milling scores. Together, these behaviors ascribe strong conflict in Sneech's relationship with Star.

(Appendix continues)

Lex (Juvenile)—Insecure Avoidant

Outlier Behaviors

This pair's relationship was characterized by low scores on contact sitting duration, maternal grooming duration and frequency, youngster and maternal responsiveness, contact sitting bout length, interactions/hour, and complexity and maternal latency to respond. They were high on absolute Z. Their initiative index was skewed toward the youngster Lex.

Mother–Juvenile Relationship Profile

Lex was low on overall time spent contact sitting with his mother Lulu and never stayed for any length of time, having no contact sitting bouts to

use to calculate his mean bout length. Lex and Lulu had the lowest interaction/hour score of the mother–juvenile pairs, coupled with the lowest juvenile score for complexity in interaction. The pair was low on maternal grooming duration, maternal grooming frequency, youngster responsiveness, maternal responsiveness, and youngster agonism, and high on initiating interactions. This pair virtually lacked a relationship. This youngster's efforts elicited no response from his mother in that his mother, Lulu, had one of the highest maternal latency to respond scores.

Received May 3, 2001

Revision received September 20, 2001

Accepted September 22, 2001 ■

Members of Underrepresented Groups: Reviewers for Journal Manuscripts Wanted

If you are interested in reviewing manuscripts for APA journals, the APA Publications and Communications Board would like to invite your participation. Manuscript reviewers are vital to the publications process. As a reviewer, you would gain valuable experience in publishing. The P&C Board is particularly interested in encouraging members of underrepresented groups to participate more in this process.

If you are interested in reviewing manuscripts, please write to Demarie Jackson at the address below. Please note the following important points:

- To be selected as a reviewer, you must have published articles in peer-reviewed journals. The experience of publishing provides a reviewer with the basis for preparing a thorough, objective review.
- To be selected, it is critical to be a regular reader of the five to six empirical journals that are most central to the area or journal for which you would like to review. Current knowledge of recently published research provides a reviewer with the knowledge base to evaluate a new submission within the context of existing research.
- To select the appropriate reviewers for each manuscript, the editor needs detailed information. Please include with your letter your vita. In your letter, please identify which APA journal(s) you are interested in, and describe your area of expertise. Be as specific as possible. For example, "social psychology" is not sufficient—you would need to specify "social cognition" or "attitude change" as well.
- Reviewing a manuscript takes time (1–4 hours per manuscript reviewed). If you are selected to review a manuscript, be prepared to invest the necessary time to evaluate the manuscript thoroughly.

Write to Demarie Jackson, Journals Office, American Psychological Association, 750 First Street, NE, Washington, DC 20002-4242.