# SOCIAL PLAY IN RHESUS MACAQUES (*Macaca mulatta*): A CLUSTER ANALYSIS[1]

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## I. INTRODUCTION

Problems frequently arise in the study of social behavior when one is called on to operationally define particular categories of behavior. Clearly, play is one such category. Gilmore (1966) notes that play seems to represent a definitionally impossible "wastebasket" category of behavior. It is quite clear that play is an easily recognizable behavioral class (Poole and Fish, 1975), as evidenced by the high interobserver agreement when animals are playing (Anderson and Mason, 1974; Loizos, 1966, 1967; Miller, 1973; Sade, 1966; Symons, 1973). However, there are real questions as to the specific behavioral characteristics which comprise play.

The identification of specific behavioral elements within play is a difficult task, particularly among primates, because

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of the rapidity and temporal lability of the behavior. It is precisely the temporal characteristics of the behavioral elements which comprise play interactions which have caused considerable controversy in the literature. For example, Loizos (1967:179), among others, notes that "...play has no formalized sequence of events, such that action A will always be followed by action B, C, or D. In play, depending upon the feedback from the object or the social partner, A may be followed with equal likelihood by B or Z." On the contrary, Müller-Schwarze (1971) found sequential stability and predictability in play sequences of blacktail deer.

Furthermore, if we review the literature we find a wide variety of definitions of play. Altman (1966) noted that play had never been satisfactorily defined and, in fact, was the most neglected dimension of animal social behavior. Given the lack of agreement over what precisely constitutes a definition of play, a structuralist position (e.g., Fagen, 1974) has been adopted which addresses not the underlying behavioral mechanisms or adaptive significance of play, but considers the form of the behavioral elements which comprise play.

In any consideration of the structure of play, one must come to grips with the problem of relying on certain intuitive typologies to define this complex behavioral element. It is tempting to rely exclusively on certain characteristics of play which allow us to achieve high interobserver reliability measures as to when animals are playing. However, researchers should strive to more objectively define such an event.

This paper attempts to empirically define social play in rhesus macaques by analyzing the social behavioral repertoire of young animals using a multivariate statistical procedure to arrive at a definition of social play in terms of the motor patterns exhibited.

## II. METHODS AND MATERIALS

### A. *Study Site*

This study was conducted at the Yerkes Regional Primate Research Center Field Station near Lawrenceville, Georgia, and involved behavioral observations of two groups of rhesus macaques, *Macaca mulatta*. These two groups (designated R-9 and R-12) are long-standing, intact social groups and were selected for the study because of large size and age/sex composition (R-9) and comparative value of observations on the same species (R-12). Long-term genealogical records are available for both groups (see Tables I and II), which allowed careful control of selection of subjects for observation. Although



*TABLE I. Genealogical Relations and Age/Sex Composition of R-9 Group*

| *Adult* | *1970* | *1971* | *1972* | *1973* | *1974* | *1975* |
|---|---|---|---|---|---|---|
| NB♀ | | ZF♂ | QG♀[a] | QH♂[a] | DJ♂[a] | GK♀ |
| RA♀ | GF♀ | EG♀ | | TH♂[a] | CJ♂[a] | ZK♀ |
| | GF♀ | | | DI♀[a] | | RK♀ |
| | | EG♀ | | | | UK♀ |
| BB♀ | IF♀ | | | YH♂ | | PK♀ |
| | IF♀ | | | | LI♀[a] | SK♂ |
| QA♀ | LF♀ | | KG♂[a] | | | |
| | LF♀ | | | | MI♀ | MK♂ |
| VA♀ | PF♀ | | SG♂[a] | BI♂ | EJ♀[a] | NK♂ |
| | PF♀ | | | | JI♀ | KK♂ |
| UB♀ | | | NG♂[a] | WH♀[a] | GJ♀[a] | JK♂ |
| QD♀ | | VF♂ | | LH♀ | | |
| SA♀ | QF♂ | | | | QI♀ | EL♀ |
| WC♀ | JF♀ | | | OH♀[a] | UI♂[a] | BL♂ |
| | JF♀ | | | | | VJ♂ |
| OC♀ | OF♀ | | AH♀[a] | NH♂ | TI♂[a] | WJ♀[b] |
| | OF♀ | | | | ZI♂ | |
| IE♀ | | | UG♀ | | II♂ | DL♂ |
| YC♀ | NF♀ | | HG♀[a] | | | |
| | NF♀ | | | | | YJ♂ |
| | | | HG♀ | | | UJ♀[b] |

*Continued on following page*

| Adult | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|
| RC♀ | | | BG♂ | | | TJ♂ |
| BD♀ | | TF♂ | | PH♂ | | HK♂[b] |
| JB♀ | | WF♀ | | KH♂[a] | HJ♀[a] | WK♀ |
| | | WF♀ | | | VI♀ | OK♂ |
| VC♀ | RF♀ | | | GI♂ | | ZJ♂ |
| | RF♀ | | | | SI♀ | YK♀ |
| FB♀ | | | | CI♀[a] | | TK♂ |
| TD♀ | | | | FI♂[a] | | |
| | HF♀ | | | | NI♂ | QK♀ |
| | MF♀ | | | | WI♀[b] | LK♂[b] |
| | KF♂ | | PG♀[a] | | | |
| | | UF♂ | YG♂ | | | |
| WA♀ | | | | | | |
| PC♀ | | | | | | |
| VD♀ | | | | | | |
| WD♀ | | | | | | |
| UA♀ | | | | | | |
| PD♀ | | | | | | |
| UE♀ | | | | | | |
| PA♀ | | | | | | |
| WB♀ | | | | | | |
| RE♀ | | | | | | |
| SE♀ | | | | | | |

Continued on following page



| Adult | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | |
|---|---|---|---|---|---|---|---|
| PE♂ | | | | | | | |
| QE♂ | | | | | | | |
| CE♂ | | | | | | | |
| OB♂ | | | | | | | |
| QB♂ | | | | | | | |
| 7♂ | 2♂ | 4♂ | 5♂ | 9♂ | 7♂ | 16♂ | 50 |
| 27♀ | 10♀ | 2♀ | 5♀ | 5♀ | 10♀ | 10♀ | 69 |

[a]Subjects.

[b]Died during course of study.

the subjects were being used concurrently in other experiments, manipulations had no observable effect on their social interactions. No changes in group composition were noted during the study except through natural causes.

The animals are housed in identical 38.5 m x 38.5 m open-air enclosures surrounded on one side by a 4.85 m high sheet metal wall and on three sides by 1.75 m of 5 cm chain link fence surmounted by 3.1 m of sheet metal [see Gordon and Bernstein (1973) for diagram of compound]. The open-air enclosures are attached to 9.3 m x 3.1 m x 2.2 m indoor quarters. Two animal-operated swing doors allow access between the indoor quarters and the outside compound. There are indoor and outdoor observation posts from which all sections of the compound can be seen (see Figure 1).

Furthermore, genetic variability between these two groups was minimized, as the smaller group (R-12) was formed from the larger group (R-9). The R-9 group was formed in 1969, with the first births occurring in 1970. The R-12 group was split from the R-9 group in 1970, with the first births in 1971 [see Bernstein, Gordon and Rose (1974a,b) for a full discussion of these group formations].

Dolhinow and Bishop (1970) have noted that play is one of the most difficult behavior patterns to study because of rapidity and variability of expression. Any detailed study of social play is destined for failure unless observation conditions are optimal. This is clearly not the case in most field

*TABLE II. Genealogical Relations and Age/Sex Composition of R-12 Group*

| Adult | 1971 | 1972 | 1973 | 1974 | 1975 | |
|---|---|---|---|---|---|---|
| AE♀ | YF♀ | RG♀[a] | | | | |
| | YF♀ | | | | BK♀ | |
| OA♀ | | MG♀[a] | RH♂[a] | IJ♂[a] | AL♀ | |
| OD♀ | | | IH♀[a] | RI♀[a] | XK♂[d] | |
| SB♀ | | LG♂[a,b] | JH♂[a] | FJ♀[a] | IK♂ | |
| SC♀ | | | AI♂[a] | BJ♂[a] | CK♂ | |
| SD♀ | | EH♀[a] | | YI♂[a] | | |
| TC♀ | | | EI♀[a] | | VK♂ | |
| TE♀ | | FG♂[a] | SH♀[a] | PI♂[a] | EK♂ | |
| VE♀ | SF♀ | OG♂[a,c] | MH♀[a] | | | |
| | SF♀ | | | | AK♀[d] | |
| YD♀ | | | ZH♂[a] | | FK♀ | |
| JC♂ | | | | | | |
| BC♂ | | | | | | |
| 2♂ | 0♂ | 3♂ | 4♂ | 4♂ | 5♂ | 18 |
| 10♀ | 2♀ | 3♀ | 4♀ | 2♀ | 4♀ | 25 |

[a]Subjects.
[b]Adopted mother MA (removed prior to study).
[c]Adopted mother SC.
[d]Died during course of study.



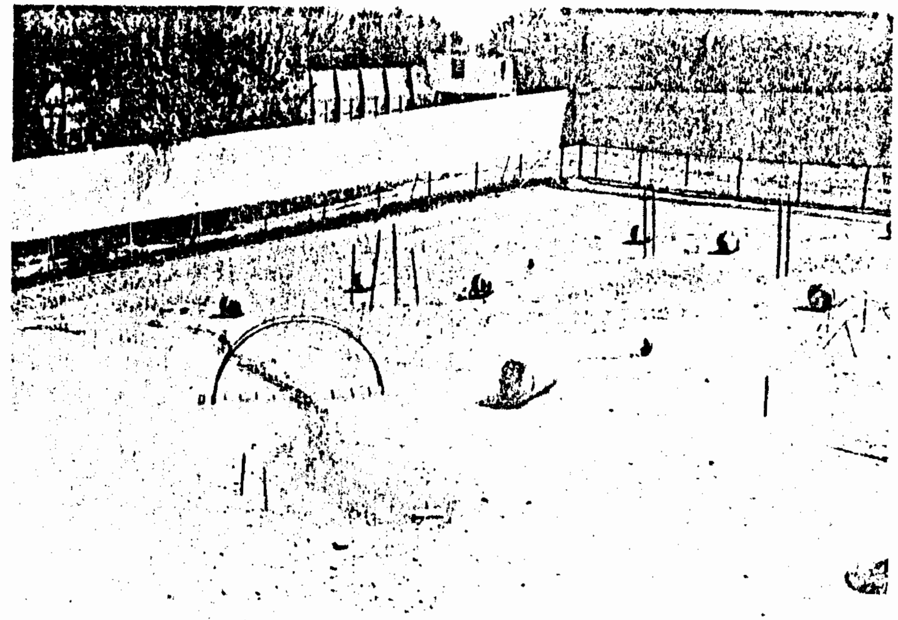

*FIGURE 1. View of the outdoor animal enclosure from the photographic platform at the Yerkes Regional Primate Research Center Field Facility.*

studies. However, to appreciate the variability of this highly social behavior, a study of play must involve observations of individuals living within a social group. Indeed, a compromise on either of these key issues would seem to limit results at the outset. Therefore, the use of captive groups of primates, housed in enclosures which allow spatial mobility, seems to offer the most suitable opportunity for the study of social play. It is precisely these factors which influenced the choice of the Yerkes Regional Primate Research Center Field Station as a study site. Further, the accessibility of two intact groups of rhesus macaques, as well as the quantity of existing data from field, laboratory and provisioned colonies, on social behavior in *M. mulatta*, argued strongly for their choice as study species.

### B. *Study Species*

Many researchers have noted that play occurs most frequently in young animals (Bekoff, 1972; Poirier, 1972; Poirier and Smith, 1974; Smith, 1972). Symons (1973) and Hinde and Spencer-Booth (1967) noted specifically that, during the first

2-1/2 - 3 years of life for rhesus macaques, maximal social play is witnessed. For that reason, a sample of young individuals was selected from each group for intensive study. Subjects were selected using the following criteria, wherever possible: 1) consideration of maternal rank, determined from existing data, individuals were selected from both high- and low-ranking mothers; 2) males and females were selected to assess the importance of gender differences on the expression of play; 3) as often as possible, siblings were selected from various matrilines to investigate certain dimensions of peer vs. sibling preference for play partners; 4) individuals were also selected which did not have a mother in the group to assess this social variable on expression of play; and 5) only individuals in their first, second and third year of life were selected. It was possible to select subjects in the large group (R-9) (n = 119) with all these criteria in mind; however, the size (n = 43) of the smaller group (R-12) precluded consideration of some of these criteria. In fact, to achieve a sufficient sample size, all individuals in their first, second and third year of life in the R-12 group were included as subjects (see Tables I and II for subject and sex designation).

### C. *Initial Pre-test Observations*

Initially, three and one-half months (approximately 350 hours) of observation were required to accurately identify each individual in the large group (R-9). Later in the study, an additional 40 pre-test observation hours were required to individually identify each member of the small group (R-12). Although all animals were tattooed with individual alphabetic codes, these were so small as to be of little use in a large open-air enclosure. Individuals had to be recognized by discrete morphological characteristics and/or individual behavior patterns.

Although a time-consuming process, this procedure allows collection of data on individual animals in a manner clearly superior to simple identification of age/sex classes. To aid in the identification process, some of the animals were captured and given a unique shave code.

### D. *Behavioral Inventory*

Any study of social behavior must begin with a well documented inventory of behavioral responses; the study of social play is no exception. "The basis for ethological investigation is the ethogram, the precise catalogue of all the behav-



practice, functional units are chosen which are neither too large nor too small, but consistent in form. However, the description of a behavior pattern is never complete in actuality, for the observer makes certain judgmental decisions on the relative importance of behaviors (Eibl-Eibesfeldt, 1975).

Wiepkema (1961) selected behavioral units utilizing several different criteria: 1) easily measurable, 2) not too rare in occurrence, 3) biologically meaningful, and 4) not entirely correlated with other variables. Norton (1968) noted that a behavioral unit consists of one or several movements occurring simultaneously or in immediate sequence with a high predictability. According to Kummer (1957), a behavioral unit is an essential core movement (Krenbewegung) which can be accompanied by typical or accessory movements. Hopf (1972) employs a similar definition in her study of squirrel monkeys. These units should be defined operationally, although the 'gestalt' of them cannot, and should not, be completely disregarded (Lorenz, 1959). The names of the units should be thought of as labels, not as *a priori* interpretations (Hopf, 1972).

van Hooff (1973) has noted that the question is how far to split movements and postures, and where to lump movements and postures to create a catalogue of meaningful units. Most catalogues, especially in laboratory studies, are relatively small, so that a great deal of lumping and/or selection inevitably must have occurred (Plutchik, 1964). "Most students of primate behaviour have not worried too much about this and have presented catalogues in a matter-of-fact manner" (van Hooff, 1973: 81).

According to Altmann (1965:492), "If one's goal is to draw up an exclusive and exhaustive classification of the animal's repertoire of socially significant behavior patterns, then these units are not arbitrarily chosen. To the contrary, they can be empirically determined. One divides up the continuum of action wherever the animals do. If the resulting recombination units are themselves communicative, that is, if they affect the behavior of other members of the social group, then they are social messages. Thus, the splitting and lumping that one does is, ideally, a reflection of the splitting and lumping that the animals do. In this sense, then, there are natural units of behavior." van Hooff (1973) continues that there are a number of behavioral elements which have characteristics which differentiate them from other elements, and cannot be divided into independently occurring subdivisions.

Social behavior of primates, then, to some extent, forms a graded continuum (e.g., touch, push, pull, hit, slap) and may exhibit similar motor elements which vary in intensity. Also, there may be a phylogenetic relationship in the degree or subtlety of the gradations, with pongids exhibiting the most in-

Frenz (1969) note, the use of too broadly defined, as well as too narrowly defined, behavioral units can reduce the validity of results. Caution should be exercised to identify socially and biologically meaningful elements.

Prior studies of rhesus macaques have included catalogues of social behavior in varying stages of completeness (Altmann, 1962; Carpenter, 1942; Chance, 1956; Hinde and Rowell, 1962; Hines, 1942; Rowell and Hinde, 1962). However, as Reynolds (1975) points out, comparisons of the results are difficult due to a variety of factors (i.e., different aims, lumping and splitting differences, usage differences). For example, Altmann (1962) employs one category, "plays with", and notes, "...play is not a single behavior pattern, but rather a complex form of behavior interactions involving many other behavior patterns in highly modified form" (Altmann, 1962:376-377). Chance (1956:4) notes that play included "(1) grasping of one animal by another, (2) attempts to bite, (3) pulling, in attempts to displace or turn over, (4) rolling over, (5) jumping: (a) in the air by itself, (b) and catching at tail or grasping, (c) and looking through its legs, (d) and losing its balance (repeatedly), (6) sliding off tree trunks, etc., (7) imitative, incomplete activities: (a) pelvic movements, (b) threats, (c) equilibratory movements and gestures, (d) biting." Also, as a distinct category, Chance (1956) included bathing activities of juveniles which, by many standards, would be playful (i.e., Symons, 1973). While Hines (1942) recognizes two forms of play, movement play and social play, he does not present an adequate operational definition for either type.

From these descriptions, considerable variability in the development of an ethogram for rhesus macaques can be noted. From these published data, a behavioral inventory already in use at the Yerkes Regional Primate Research Center for observations on rhesus macaques (Bernstein, personal communication) and some 10 hours of filmed interactions, a catalogue of 118 behaviors was developed [see Smith (1977) for complete listing and operational definitions]. Included in this inventory are a variety of behaviors, not all of which are playful. In fact, there are no molar (large, inclusive/functional) behavioral categories in the inventory, for it was felt that premature lumping (e.g., sexual, agonistic, play) would obscure the variability in expression of patterns of interest.

Frequently, behavior patterns have been classified in terms of their function; however, this presupposes a knowledge of causation which is one of the aims in the study of behavior (van Hooff, 1973). Ethologists have cautioned against the use of functional classifications on an *a priori* basis precisely for this reason, not only in classification, but also in the description of the behavioral elements (Baerends, 1956; Hinde, 1966; Tinbergen, 1963; van Hooff, 1973). Furthermore, since formidable definitional problems exist with social play (cf., Rowell, 1966, 1967, 1969) as a molar behavioral category, every attempt was made to define as precisely as possible the component behaviors within a play bout.



### *E. Data Collection Procedures*

Observations began 16 October, 1974, and terminated 17 October, 1975. During this period, over 750 hours of observation yielded 160 hours of quantified data (120 hours for R-9; 40 hours for R-12). Data were collected only when the ambient temperature was below 29.4° C and above 7.2° C, for it has been demonstrated (Bernstein, 1972, 1975; Bernstein and Mason, 1963) that temperatures outside this range markedly affect general activity levels and, thereby, the expression of social play. Play does occur at temperatures outside this range, but these limits were observed in order to maximize data, by sampling during periods of maximum activity for the entire group. Data were also not collected in rainy weather, as this condition has been demonstrated to minimize social play (Bernstein, 1972, 1975; Oakley and Reynolds, 1976). All observations were made from the outdoor photographic platform, with animal access to indoor quarters restricted. Therefore, all subjects were constantly in view.

### *F. Sampling Techniques*

The focal animal sampling technique (Altmann, 1974) was used during the entire study, although qualitative notes were taken to capture aspects of interactions not usually scored. The focal animal technique is particularly appropriate for the study of social play, as it is designed to record all occurrences of specified interactions of an individual during each sampling period. Furthermore, under some conditions, one may assume that a complete record is obtained of the focal animal's actions as well as the actions directed toward him by others.

Often results of focal animal sampling, and other techniques for that matter, are used to make statements about frequency of interactions when they are actually statements about rates (Altmann, 1974). Recognizing that there are important theoretical differences concerning the rate of responses and duration, data were collected on the time of onset of each interaction and the termination of those durational responses. For example, slaps, bites, jump ons, etc., are of relatively short duration and are significant in terms of their frequency of occurrence, while grooms, maternal behaviors, etc., are important for their duration as well. Consequently, data were recorded on: 1) the focal animal, 2) the interactant, 3) the sequence of interactions, 4) the time of occurrence, 5) direction of interaction, and 6) the onset and termination of durational behaviors.

The 44 focal animals were observed individually for six-minute observation periods. The duration of the testing interval was, as are most conditions in design of a study, a compromise between prolonged sessions in which the behaviors of an individual could be monitored in half-hour blocks, for example, and short sessions but of much greater frequency (e.g., 30 seconds). Since the sequence of behaviors during the testing sessions was of interest, the duration of the test interval should be of sufficient length to include an adequate sample of the longest sequences of interest (Altmann, 1974). Independent measurement of the average duration of 100 play bouts [defined by criteria suggested by Bernstein (1975)] yielded a mean of slightly less than 1-1/2 minutes. Therefore, it was concluded that a six-minute test session would be of sufficient duration for adequate sampling. Individuals were chosen at random from the subject list without replacement for a given day's observations, and observed for a six-minute test session. If, however, an interesting interaction sequence was in progress at the termination of the test interval, data were collected until the termination of the interaction, but used only to add qualitative detail, and are not included in any statistical analysis.

In sum, focal animal observations yielded a total of 1,600 six-minute observation sessions (1,200 for R-9; 400 for R-12). In other words, during the course of the study, each focal animal in the R-9 group was observed for five hours, while each subject in the R-12 group was observed for two hours. Observations were conducted when the ambient temperature was within the predefined range; however, time of day and number of observations per month were not controlled, although efforts were made to sample behavior throughout the diurnal and annual cycle.

Because of the rapidity and temporal lability of much of rhesus behavior, the traditional checklist approach was not employed. However, the same cautions were used in tape recording the data as would be employed in the use of the checklist approach [vide Hinde (1973) for details]. Interactions were dictated onto cassette tapes using various recorders. Observations were aided by a pair of 7 x 50 wide angle binoculars.

Tape recorded data were then transcribed into a sequential event format of, basically, who, does what, to whom. Using the original data tape and the typed scenario, the times for



the onset of all behaviors and the termination of some (e.g., maternal, groom, huddle) were recorded by playing the tape in real time and noting times after the start of each session. Therefore, not only was the time recorded in relation to the onset of the test session, but also in relation to a 24-hour clock.

During the course of the study, periodic filming allowed continual reevaluation of categories being scored, as well as preventing 'observer drift' as greater facility was acquired in making observations (Poole, 1973). Identical testing and data collection procedures were employed for both groups.

Data were then coded onto Fortran coding forms and then keypunched. Observations over the twelve-month period on both groups yielded in excess of 40,000 separate interactions. After keypunching, data were subjected to a variety of editing programs to detect coding and/or keypunching errors.

### G. *Multivariate Techniques for Analysis of Behavioral Data*

Recognition of problems of classification of behavior and search for underlying causal mechanisms can be attributed to the work of classical ethologists on predominantly non-mammalian forms (vide Hinde, 1966; Marler and Hamilton, 1966; Tinbergen, 1942). These early studies are significant, for they attempt to present an analysis of the structure of the behavior on an empirical rather than intuitive basis.

A structural analysis of behavioral data and the classification of behavioral elements on the basis of temporal relationships seems the logical preliminary to the investigation of the causal factors and functional aspects of behavior (van Hooff, 1973). For such analysis, many researchers have turned to multivariate statistical techniques, largely derived from information theory. While Haldane and Spurway (1954) were the first to use information theory on nonhuman behavioral data, a number of researchers have followed, employing a variety of techniques [cf., Baerends and van der Cingel (1962) for displays of common herons; Dingle (1972) for aggressive behavior in stomatopods; Fentress (1972) for grooming in mice; Slater and Ollason (1972) in a study of behavior of male zebra finches; Steinberg and Conant (1974) for intermale behavior of grasshoppers; and Wiepkema (1961) in a study of reproductive behavior in bitterlings].

Several researchers have used multivariate analysis of the temporal relationship of behavior in primates (Altmann, 1965, 1968; Chamove, Eysenck and Harlow, 1972; Jensen, Bobbitt and Gordon, 1969; Locke *et al.*, 1964; Maurus and Pruscha, 1973; Morgan *et al.*, 1976; Pruscha and Maurus, 1973; van Hooff, 1970, 1973). However, the possibilities for use of these techniques in understanding and explaining behavior seem in their infancy.

Basically, it seems that there exist four alternative approaches to the problem of the sequential and/or temporal analysis of behavioral data:

1. *Correlation Techniques*. There exist a variety of techniques for measuring frequencies of different behavior patterns within a series of time units to determine whether they are positively or negatively correlated (e.g., Andersson, 1974; Baerends, 1956; Bekoff, n.d.; Delius, 1969; Heiligenberg, 1973). Positive correlations indicate relatively similar causal bases, low correlations indicate the causal bases are unrelated, and negative correlations indicate an inhibiting relationship (Hinde, 1966). However, several problems may plague the researcher: (a) if the number of behavioral elements is large, the interpretation of a great number of correlation coefficients that can be obtained by this method can be difficult (van Hooff, 1973); (b) if the probability of the occurrence of a particular set of behaviors does not remain constant over time, nonstationarity becomes a problem, but not as acute as in other techniques (for further discussion of stationarity, see factor analysis technique). A check of the data for stationarity is a first requirement (Slater, 1973), although diurnal cycles (e.g., Aschoff, 1967; Palmgren, 1950) and short-term cycles (Richter, 1927; Wells, 1950) may render the stationarity assumption untenable; (c) the main difficulty is that results depend on the choice of time unit (Slater, 1973). Although two acts are significantly correlated at one-half hour intervals, this is not necessarily true when data are organized in 10-second intervals.

2. *Markov Analysis*. A sequence of behaviors can be described by a first-order Markov chain if the probabilities of different acts depend on the immediately preceding act and not on any earlier ones (Billingsley, 1961; Cane, 1961). However, Markov chains can extend longer than just the preceding interaction. An *nth* order approximation is possible, for a species with a repertoire of *r* mutually exclusive patterns of social behavior will have $r^{n-1}$ states, corresponding to the *n-1* event before the *nth* event (Altmann, 1965). This type of analysis has been used to describe social communication in rhesus macaques (Altmann, 1965), courtship patterns in glandulocaudine fish (Nelson, 1964), sequences of bird song in the cardinal and the wood pewee (Chatfield and Lemon, 1970), and suggested as a technique for analyzing social play (Bekoff, 1975). Here, too, methodological problems confront the researcher: (a) as noted before, stationarity poses considerable problems. As Slater (1973:145) noted, "...assuming stationarity of behavioral events is tantamount to ignoring the possibility that motivational events occur." The effect of diurnal, circadian or seasonal cycles may not allow the assumption of stationarity; (b) Bekoff (n.d.) notes that conditions of observation of social behavior often preclude the use of Markov analysis because of the stationarity problem [e.g., two individuals' interaction, data from different individuals is lumped together (Chatfield, 1973)].



3. *Factor Analysis*. Factor analysis is a multivariate statistical method, not primarily concerned with sequencing, but used to detect association patterns between behaviors. Factor analysis has been used by a number of researchers (Baerends and van der Cingel, 1962; Baerends *et al.*, 1970; Chamove, Eysenck and Harlow, 1972; Locke *et al.*, 1964; van Hooff, 1970; Wiepkema, 1961). Using this method, a small number of hypothetical variables are extracted, the existence of which could account for most of the observed correlations between acts. It is assumed that the behavior patterns (variables) do not depend causally on each other, but only on the underlying postulated factors (Blalock, 1968; Slater, 1973). The choice between factor analysis and Markov analysis appears to depend mainly on whether the researcher believes "sequence effects" or "motivational state" to be most important in determining the relationship between behaviors. If "sequence effects" are felt to be more important, then it is useful to describe the probability of the occurrence of a particular act at a point in time, in terms of the sequence of acts which preceded it. If, on the other hand, the emphasis is on motivational state, an association between acts is taken to mean that there are common causal factors underlying the behaviors, and the factor on which they have a high loading may represent a motivational state [e.g., aggressive, sexual, nonreproductive (Wiepkema, 1961); affinitive, play, aggressive (van Hooff, 1970)] (Slater, 1973).

Several criticisms of the use of factor analysis in ethological research have been discussed by Andrew (1972), Overall (1964) and Slater and Ollason (1972). Basically, the question is the interpretation of the underlying variables. Wiepkema (1961) referred to factors as "tendencies", Baerends *et al.* (1970) note that factors were areas of high density within the causal network, while van Hooff (1970) called his factors main motivational systems. Slater (1973:145) notes that, "...it is doubtful whether the extraction of factors which are themselves of complex causation advances understanding."

4. *Cluster Analysis*. Morgan *et al.* (1976) note that there are a number of ways of tackling multivariate data.

Cluster analysis seems preferable to other techniques, as it makes fewer assumptions about the data and is, therefore, easier to understand. Maurus and Pruscha (1973) argue strongly for the use of cluster analysis over other techniques, especially factor analysis, for the following reason. With factor analysis techniques, frequency data are interpreted as points in Euclidian space, which is against the nature of the data. van Hooff (1970) subjected behavioral data to a factor analysis in the following manner: for each cell of the transition matrix (a matrix where the behaviors of the inventory were listed down the rows and across the columns, with the frequency of two acts occurring in succession noted at the intersection). For example,

Behavior from Inventory (Succeeding)

| Behavior from Inventory (Preceding) | A | B | C | |
|---|---|---|---|---|
| A | 3 | 7 | 8 | 18 |
| B | 2 | 1 | 5 | 8 |
| C | 8 | 3 | 2 | 13 |
| | 13 | 11 | 15 | 39 = N |

which can be read as A preceded A on three occasions; A preceded B on seven occasions, etc. The expected frequency for each cell in our example could be calculated by taking the row total for a particular cell times the column total for that cell divided by the total N.

$$e = \frac{\text{row total for particular cell X column total for particular cell}}{N}$$

o = observed value for particular cell

N = matrix total

To minimize the effect of random variation, van Hooff (1973: 132) used the following:

$$q = \frac{o-e}{\sqrt{e}} \quad \text{(eccentricity coefficient)}$$

o = observed value for particular cell



Then (van Hooff, 1973), a matrix was constructed consisting of the Spearman rank-correlation coefficients of two behavior units which were then subjected to factor analysis, i.e., Spearman correlation coefficients versus the actual raw data, may offer difficulties in interpretation of results (Maurus and Pruscha, 1973).

van Hooff (1973) further subjects his data to a cluster analysis using the hierarchical method suggested by McQuitty (1966). However, for the present analyses, the technique suggested by Orloci (1967, 1968) in a study of plant communities seems more appropriate because, as Maurus and Pruscha (1973: 122) note, "...the original frequencies are preserved at every step and the data are never subjected to an algorism which is against the nature of these data."

## *II. Single Link Cluster Analysis*

Following the technique described by Maurus and Pruscha (1973), behavioral observations were reduced to a transition matrix, n(h,k) is the number of times actions h and k occur in succession in a series of observations (see preceding example). Furthermore, these actions must have occurred within one 6-minute test session for a given focal subject. The total frequency of the matrix, n, equals the total observations in the study.

There are many alternative cluster analysis procedures [vide Cormack (1971) for a review], but the "agglomerative clustering method", or single link technique, was chosen. This technique has been applied to diverse biological data (Cole, 1969; Orloci, 1967, 1968; Sokal and Sneath, 1973). Using this procedure, each behavior forms a different class, m (a subset of behaviors from the original catalogue), at the starting procedure (step 0). Thus, at step 0, m = N, the number of behaviors in the catalogue equal the number of classes, m. In the case of the present analysis, m = 118.

In the first step, two behaviors are chosen from the catalogue and combined into one class: m = N-1. This procedure is then repeated until all actions are combined into one class: m = 1. As a result, a hierarchy of classes becomes more and more comprehensive, and can be depicted in a dendogram (see Figure 2).

The choice of two classes, m, for combination can be illustrated in a transition matrix (M1). Given m classes of behaviors $A_1, A_2, \ldots A_m$, the transition matrix can be represented as:

$$n(A_i, A_j)i, j = 1,\ldots,m$$

that pair out all of $\binom{m}{2}$ pairs $A_i$, $A_j$, $i \neq j$, is combined into a new class for which the new transition matrix (the matrix generated after the combination of $A_i$, $A_j$) shows the maximum transinformation. In other words, behaviors are paired together (clustered) by taking all combinations of pairs within the matrix and collapsing those two that have maximum transinformation at that step.

The transinformation, T, of a frequency matrix is a measure of the relation between the row and column categories. The properties of T are seen at its extreme values. When T = 0, the sequence of behaviors is stochastically independent; when T reaches a maximum, each behavior is fully determined by the preceding one [for a more detailed review of the properties of T, see Khinchin (1957)]. Maurus and Pruscha (1973) use this method, establishing a hierarchy of classifications using the transinformation as the criteria of selection when the observation data form a contingency table. The transinformation measure, T (Pruscha and Maurus, 1973), is the quantity

$$T = \sum \frac{n_{ij}}{n_{..}} \log \frac{n_{ij} n_{..}}{n_{i.} \, n_{.j}}$$

where frequencies $n_{ij}$, $n_{i.}$, etc., are defined as usual in the case of transition matrices (Billingsley, 1961; Fano, 1961). The application of this technique to a matrix in which the rows and columns represent the same set of characters, the catalogue of behaviors, requires a few modifications [vide Maurus and Pruscha (1973:110) for details].

For purposes of analysis, only social behaviors (i.e., not self-directed, or used to signal the termination of a behavior) occurring with more than 0.01% of the total frequency of interactions (N = 47) were used. Interactions for all age/sex classes were lumped together for purposes of this analysis, although admittedly variation clearly exists. Therefore, the original matrix (step 0) was a 47 x 47 table.

One of the problems in using the cluster analysis method is determination of the best possible clustering arrangements, those most closely related to the realities of behavior. Maurus and Pruscha (1973) note difficulties here, and resort to the use of a probabilistic interpretation of the transinformation of a transition matrix. Following Anderson and Goodman (1957), they use a chi-square function where, with a sufficiently large n, 2T is a chi-square with $(N-1)^2$ degrees of freedom. However, in this study, the $\chi^2$ values fall into a region which cannot be distinguished from 1, so an alternative approach was adopted as a way of interpreting the best linkages for the clusters. As an alternative, because of the large number of degrees of freedom (df = 2116, at step 0), the



expression $\sqrt{2\chi^2} - \sqrt{2df-1}$ (Blalock, 1972) was used as a normal deviate with unit variance, and the corresponding Z statistic was calculated (see Figure 2). At the step where the Z value reached maximum, the best clustering of the data had been reached. The Z values at each fifth step in the clustering procedure are shown for clarity on the ordinate of the dendogram (Figure 2). It should be noted that the use of the Z statistic, or other techniques, is simply an indicator of the best cluster and, as such, is superior to an intuitive guess, but is not a true inferential statistical technique.

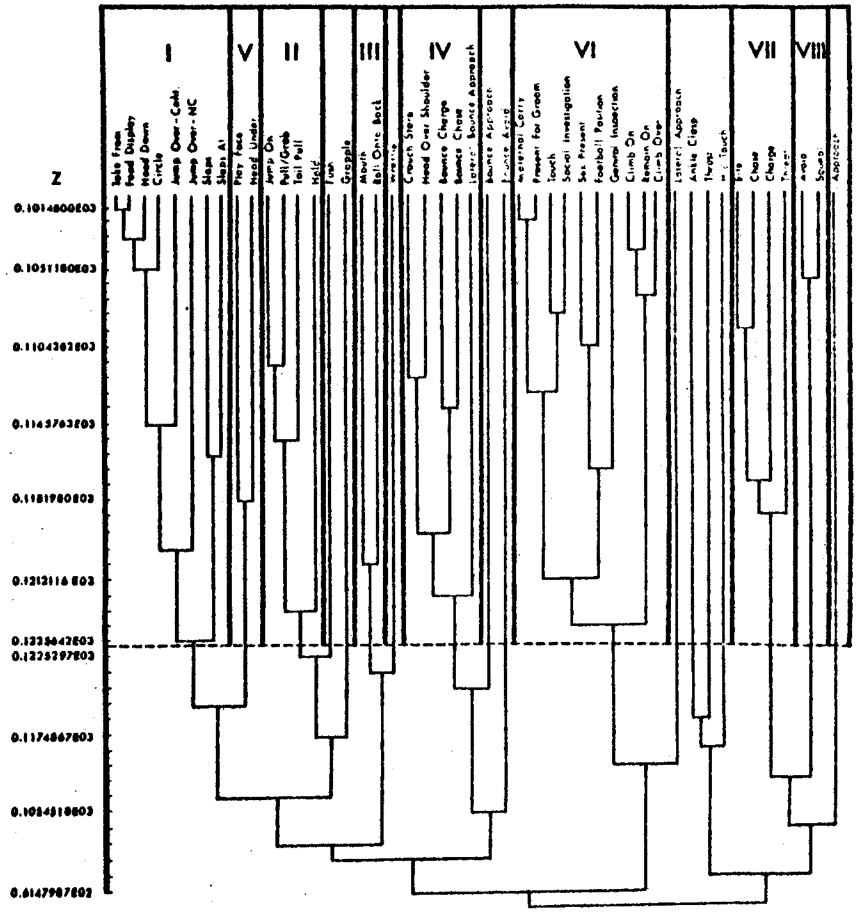


*FIGURE 2. Single link dendogram of rhesus social behaviors used in the analysis. The dotted horizontal line represents the optimum clustering step. Z scores are shown for every fifth clustering step. The dotted vertical lines partition the various clusters.*

## III. RESULTS

Data on over 14,000 social interactions for the R-9 group were analyzed by the cluster analysis technique previously described. Only social behaviors with a frequency of greatdr than 0.01% of the total were selected from the catalogue (see Table III), for it was felt that the inclusion of low frequency events would add little to the analyses. Maurus and Pruscha (1973) in a study of social communication in captive squirrel monkeys included only those behaviors occurring with a frequency of greater than 0.05% in their cluster analysis, for behaviors with lower frequency could bias the data. Also, durational behaviors (e.g., maternal, groom), maintenance behaviors (e.g., feeding, drinking), and some clearly non-playful behaviors (e.g., huddle) were excluded from these analyses.

The results of the cluster analysis are depicted in Figure 2, which is a graphic representation of the clusters of the 47 selected behaviors. This graphic representation follows the general convention suggested by Maurus and Pruscha (1973), Morgan *et al.* (1976) and Jardine and Sibson (1971) for single link cluster analysis. The behaviors have been arranged in such a fashion to best represent the clustering patterns. As can be seen at the final step in the clustering procedure, all behaviors are linked together, but this is relatively meaningless, as one would expect all social behaviors to form an integrated, interrelated system. The relations of the behaviors, to be sure, are dependent on the level of the analysis, but the structure is clearly of a hierarchical nature. At one level, the specific elements of the inventory are emphasized, while the common dimensions of groupings of elements can be seen at another (van Hooff, 1973).

When all observations are combined, several interesting patterns emerge. Using the horizontal dotted line in Figure 2 as an indicator of the best clusters, it is clear that several prominent clusters of behaviors are present, while other behaviors are not linked to any of the existing clusters. For example, *take from, food display, head down, circle, jump over with contact, jump over without contact, slaps,* and *slaps at* are all joined together; however, *push, grapple,* etc., are not linked at the optimum cluster step, although these "isolated" behaviors ultimately join with clusters of behaviors.

### A. *Play Clusters*

Lumping elements of the behavioral inventory into clusters is helpful in allowing the association of behaviors to become more apparent, but one is faced with the problem of assigning



*TABLE III. Social Behaviors Selected from the Behavioral Inventory and Used in the Cluster Analysis*

| Behavior[a] | Frequency | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | R-9 | | | R-12 | | | | |
| | I[e] / R | | | | | | | |
| *Take From* | 7 / 13 | 20 | (0.14)[b] | 0 / 2 | 2 | (0.06)[c] | 22 | (0.13)[d] |
| *Food Display* | 8 / 9 | 17 | (0.12) | 4 / 0 | 4 | (0.12) | 21 | (0.12) |
| *Head Down* | 5 / 11 | 16 | (0.11) | 1 / 1 | 2 | (0.06) | 18 | (0.10) |
| *Circle* | 26 / 2 | 28 | (0.20) | 12 / 3 | 15 | (0.49) | 43 | (0.24) |
| *Jump Over Contact* | 181 / 183 | 364 | (2.59) | 31 / 22 | 53 | (1.57) | 417 | (2.39) |
| *Jump Over Non-Contact* | 175 / 197 | 372 | (2.65) | 49 / 29 | 78 | (2.32) | 450 | (2.58) |
| *Slaps* | 94 / 157 | 251 | (1.79) | 12 / 25 | 37 | (1.10) | 288 | (1.65) |
| *Slaps At* | 87 / 42 | 129 | (0.92) | 24 / 17 | 41 | (1.22) | 170 | (0.97) |
| *Play Face* | 226 / 205 | 431 | (3.07) | 72 / 47 | 119 | (3.53) | 550 | (3.16) |
| *Head Under* | 81 / 75 | 156 | (1.11) | 17 / 8 | 25 | (0.74) | 181 | (1.04) |
| *Jump On* | 79 / 48 | 127 | (0.90) | 2 / 2 | 4 | (0.12) | 131 | (0.75) |
| *Pull/Grab* | 107 / 81 | 188 | (1.34) | 12 / 11 | 23 | (0.68) | 211 | (1.21) |
| *Tail Pull* | 54 / 37 | 91 | (0.65) | 8 / 7 | 15 | (0.44) | 106 | (0.61) |
| *Hold* | 321 / 279 | 600 | (4.27) | 59 / 73 | 132 | (3.92) | 732 | (4.20) |
| *Push* | 325 / 335 | 660 | (4.69) | 48 / 46 | 94 | (2.79) | 754 | (4.33) |
| *Grapple* | 564 / 280 | 884 | (6.29) | 110 / 69 | 179 | (5.31) | 1063 | (6.10) |

*Continued on following page*

| Behavior[a] | R-9 | | | R-12 | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Frequency | | | | | | | |
| Mouth | 424/357 | 781 | (5.55) | 69/77 | 146 | (4.33) | 927 | (5.32) |
| Roll Onto Back | 6/3 | 9 | (0.06) | 1/0 | 1 | (0.03) | 10 | (0.06) |
| Wrestle | 266/117 | 383 | (2.72) | 24/13 | 37 | (1.10) | 420 | (2.41) |
| Crouch Stare | 31/17 | 48 | (0.34) | 12/1 | 13 | (0.39) | 61 | (0.35) |
| Head Over Shoulder | 46/33 | 79 | (0.56) | 13/5 | 18 | (0.53) | 97 | (0.56) |
| Bounce Charge | 25/19 | 44 | (0.31) | 8/8 | 16 | (0.48) | 60 | (0.34) |
| Bounce Chase | 272/229 | 501 | (3.56) | 63/54 | 117 | (3.47) | 618 | (3.55) |
| Lateral Bounce Approach | 103/83 | 186 | (1.32) | 27/24 | 51 | (1.51) | 237 | (1.36) |
| Bounch Approach | 315/226 | 541 | (3.85) | 9/7 | 16 | (0.48) | 557 | (3.20) |
| Bounce Avoid | 287/236 | 523 | (3.72) | 122/94 | 216 | (6.41) | 739 | (4.24) |
| Maternal Carry | 3/25 | 28 | (0.20) | 0/2 | 2 | (0.06) | 30 | (0.17) |
| Present for Groom | 33/28 | 61 | (0.44) | 7/14 | 21 | (0.62) | 82 | (0.47) |
| Touch | 24/21 | 45 | (0.32) | 6/6 | 12 | (0.36) | 57 | (0.32) |
| Social Investigate | 20/9 | 29 | (0.21) | 12/6 | 18 | (0.53) | 47 | (0.26) |
| Sex Present | 67/62 | 129 | (0.92) | 28/27 | 55 | (1.63) | 184 | (1.06) |
| Football Position | 10/14 | 24 | (0.17) | 9/5 | 14 | (0.42) | 38 | (0.22) |
| Genital Inspection | 29/19 | 48 | (0.34) | 5/7 | 12 | (0.36) | 60 | (0.34) |
| Climb On | 21/10 | 31 | (0.22) | 2/1 | 3 | (0.09) | 34 | (0.19) |

Continued on following page



| Behavior[a] | R-9 | | | R-12 | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Frequency | | | | | | | |
| Remain On | 21/3 | 24 | (0.17) | 6/0 | 6 | (0.18) | 30 | (0.17) |
| Climb Over | 111/76 | 187 | (1.33) | 49/32 | 81 | (2.40) | 268 | (1.54) |
| Lateral Approach | 1493/1490 | 2983 | (21.22) | 631/619 | 1250 | (37.11) | 4233 | (24.29) |
| Ankle Clasp | 49/46 | 95 | (0.68) | 23/8 | 31 | (0.92) | 126 | (0.72) |
| Thrust | 33/30 | 63 | (0.45) | 18/6 | 24 | (0.71) | 87 | (0.49) |
| Hip Touch | 64/61 | 125 | (0.89) | 27/11 | 38 | (1.13) | 163 | (0.94) |
| Bite | 16/22 | 38 | (0.27) | 1/6 | 7 | (0.21) | 45 | (0.26) |
| Chase | 23/21 | 44 | (0.31) | 1/8 | 9 | (0.27) | 53 | (0.30) |
| Charge | 22/34 | 56 | (0.40) | 7/18 | 25 | (0.74) | 81 | (0.46) |
| Threat | 31/85 | 116 | (0.83) | 19/33 | 52 | (1.54) | 168 | (0.96) |
| Avoid | 437/270 | 707 | (5.03) | 143/66 | 209 | (6.21) | 916 | (5.26) |
| Squeal | | 17 | (0.12) | | 5 | (0.15) | 22 | (0.13) |
| Approach | 962/818 | 1780 | (12.66) | 28/12 | 40 | (1.19) | 1820 | (10.44) |
| | | 14,059 | | | 3,368 | | 17,427 | |

[a]See Smith (1977) for operational definitions.

[b]Percent of total for R-9.

[c]Percent of total for R-12.

[d]Percent of total (R-9 and R-12).

[e]$\frac{I}{R} = \frac{\text{Initiates}}{\text{Receives}}$

labels to these various clusters. Rather than use the traditional classification of types of play (i.e., approach-avoid, rough-and-tumble), the five clusters have been designated play classes (PI-V), and are represented as the first five clusters on the dendogram. It seems unwise to assign traditional labels to these classes, for considerable subjective impression exists as to which motor patterns should be included in the traditional classes. Further, in some cases, these traditional labels would be misleading as to the types of behaviors included in each class.

The use of the cluster analysis method allows the empirical categorization of behavioral elements based on an analysis of causal similarities. However, the clusters of behavior, although having similar causal mechanisms, do not allow for unwarranted assumption of unitary causal forces. Each cluster may, indeed, have its own underlying causal base, and in all analyses are treated individually. As van Hooff (1973) noted, these statistically defined clusters do not allow inference as to the physiological basis of the underlying causal mechanisms, although cluster analysis allows a starting point for investigations of this type (e.g., Jones, 1968; Maurus and Pruscha, 1973).

The classification of social behavior patterns by nonhuman primate researchers has typically been on a qualitative rather than an empirical basis. The molar behavior categories, traditionally derived from functional considerations, most commonly recognized are, for example: contact aggression, noncontact aggression, submission, sexual, grooming, other social (Bernstein *et al.*, 1974a), agonistic and non-agonistic (Kaufmann, 1967), aggression, sexual, anxiety, affinity, play (Alexander and Harlow, 1965), and play, fear and aggression-hostility (Chamove *et al.*, 1972). Although these molar categories are essentially validated by this study, the lack of empirical basis, other than face validity, for assigning these labels by many researchers is troublesome. Table IV presents a summary of the cluster play classes, with their component behavior patterns. As can be seen, it is difficult to categorize these play classes into traditional social play classifications (e.g., contact, rough-and-tumble, approach-withdrawal).

Intuitively, one might expect other behaviors to be included in these clusters (e.g., push, grapple, wrestle, bounce approach, bounce avoid), but since they were not linked with existing clusters at the criterion point, they will not be treated in this report. Admittedly, if the cluster analysis had been performed on each age/sex class independently, some variation in results may have been noted; however, comparisons across age/sex classes would have been difficult.

TABLE IV. *Five Play Classes (PI-PV), Their Behavioral Components, Frequency of Occurrence, and Mean Hourly Rate for All Subjects by Group*

| Play Class | Behavioral Components[a] | Frequency R-9 | Frequency R-12 | Frequency Total | Mean Hourly Rate R-9 | Mean Hourly Rate R-12 | Mean Hourly Rate Total |
|---|---|---|---|---|---|---|---|
| PI | take from, food display, head down, circle, jump over-contact, jump over-noncontact, slaps, slaps at | 1884 (27.2)[b] | 442 (25.4) | 2326 (26.9) | 15.70[c] | 11.05[d] | 13.38[e] |
| PII | jump on, pull/grab, tail pull, hold | 1470 (21.3) | 305 (17.5) | 1775 (20.5) | 12.23 | 7.62 | 9.92 |
| PIII | mouth, roll onto back | 1236 (17.9) | 292 (16.8) | 1528 (17.6) | 10.38 | 7.30 | 8.84 |
| PIV | crouch stare, head over shoulder, bounce charge, bounce chase, lateral bounce approach | 1410 (20.4) | 417 (23.9) | 1827 (21.1) | 11.64 | 10.42 | 11.03 |
| PV | play face, head under | 917 (13.3) | 286 (16.4) | 1203 (13.9) | 7.68 | 7.15 | 7.42 |
| TOTAL | | 6917 | 1742 | 8659 | | | |

[a] See Smith (1977) for operational definitions.
[b] Percent of total.
[c] Hourly rate (120 hours total - 5 hours/subject).
[d] Hourly rate (40 hours total - 2 hours/subject).
[e] Mean hourly rate for both groups combined.

## IV. DISCUSSION

As Marler and Hamilton (1966) note, the description and classification of behavior may be the most important single issue in many ethological studies. The precise establishment of a systematic classification scheme of behavior patterns was first suggested by Jennings (1906), who referred to them as action systems.

A systematic catalogue of behavior patterns consists of physical descriptions (Hinde, 1966), which ideally should include all the details of the behavioral event. In actuality, this is an exceptionally difficult task, for an observer typically omits those characteristics of the behavioral event which are not important to him. As Hinde (1971:412) notes, "...we must therefore be constantly aware of the extent to which our categories really do represent discontinuities and the degree to which they are a matter of convenience." In any event, ethological studies should start with accurate descriptions of the behavioral repertoire of the species, the ethogram (Eibl-Eibesfeldt, 1975). However, the description of behavior patterns is only the first step in the classification of behavior.

Problems manifest themselves when the observer begins to classify relatively stereotyped behaviors into classes which are recognizable in different animals and in different encounters. In general, behavior can be classified as: (a) easily recognizable patterns, which are often only motor acts (e.g., bite, slap); or (b) sequences of movement which have a specified goal, "strategems" (e.g., attack, avoid, chase) (Poole, 1973). Clearly, the behavioral inventory used in this study is composed of a combination of motor acts and strategems. This combination, however, does not place a serious limitation on this study, but merely points out that often functional, rather than purely descriptive, labels are attached to behaviors, although caution in interpretation should be exercised when this procedure is employed.

Cluster analysis leads to a classification of behavior, which results in lumping of certain actions together, thereby revealing the integrated structure of the behavioral repertoire. The hierarchical nature of the structure is revealed through the cluster analysis. First, cluster analysis demonstrates that all elements represent a collection of individual behaviors and, as more individual types are classed together, higher and higher orders of hierarchical structures are revealed (van Hooff, 1973). The identification of the structure of the behavioral repertoire adds to our understanding of the integrated systems of the behaviors which are present.

Multivariate statistical techniques, especially cluster



analysis, reveal the general aspects of frequently occurring phenomena; however, the specific acts of unique occurrences, although possibly theoretically significant, find little expression in these statistical techniques. Certainly, when considering the behavior of animals in a variety of ecological contexts, the probability of finding such unique events increases, as the system of variables which affect behavior increases. The tendency for increasing complexity in the integration of behavior and the increasingly greater role of perception and higher integrative neural functions is present as one moves toward more complex organisms. This tendency should alert us to Rioch's (1967) and Mason's (1965) warnings that attempts at quantification of behavior should not be at the complete expense of the qualitative and anecdotal narrative, which often is the only possible avenue to understanding these unique behavioral events.

In sum, multivariate statistical analysis offers the possibility of quantifying behavioral observations in such a manner that underlying patterns or associations become apparent, which otherwise might be obscured. Nonetheless, qualitative observations are necessary to add a meaningful perspective to these data.

### A. *Social Play Defined*

Cluster analysis generated results which are intrinsically interesting, but become more intriguing when the common, or generally accepted definitions of social play are considered. Rather than an undifferentiated uniform behavioral event, results indicate that in this experimental setting, social play is organized into at least five different classes of behavior, which occur as temporally distinct units. Total social play comprises 49.20% of the total social interactions (n = 14,059), and approximately 20.42% of the total behavioral observations (n = 33,869) for the R-9 group.

Although a number of investigators have described social play in rhesus macaques (i.e., Breuggeman, 1976; Harlow, 1959, 1962, 1964; Harlow *et al.*, 1963; Hinde and Spencer-Booth, 1967; Lichstein, 1973a,b; Loy and Loy, 1974; Reynolds, 1972; Rosenblum, 1961; Rosenblum *et al.*, 1969), none have used multivariate statistical analyses to define in quantitative terms the behavior patterns which comprise this behavioral category. In the study of primate behavior, relatively few attempts have been made to use multivariate statistics in this manner, save the work of Altmann (1965, 1968), Chamove *et al.* (1972), Jensen *et al.* (1969) and Locke *et al.* (1964). Furthermore, cluster analysis, specifically, has found application only in the work of Maurus and Pruscha (1973), Morgan *et al.* (1976), Pruscha and Maurus (1973) and van Hooff (1970, 1973). None of these investigators, however, has been specifically concerned with social play. In this light, this study demonstrates that such approaches can be fruitfully employed to understand the variability of expression in social play. Although not a "cure-all" for problems of classification of behavior, cluster analysis presents, at least, an attractive alternative.

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