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Feeding competition in Rhesus monkeys: The transfer of behavioral competition to a computer task paradigm

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Feeding Competition in Rhesus Monkeys:
The Transfer of Behavioral Competition
to a Computer Task Paradigm

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B.A., College of Wooster, 1989

Presented in partial fulfillment of
the requirements for the degree of

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Feeding Competition in Rhesus Monkeys: The Transfer of Behavioral Competition to a Computer Task Paradigm

Director: David A. Strobel

This experiment was conducted using four Rhesus monkeys to compare two conditions of competition for food. Phase I involved a behavioral competitive situation in which dyads of monkeys were placed together to compete for a single food source. Phase III was conducted using the same dyads in order to assess each animals' performance during a computer game involving food competition. Measures taken included the winner within each dyad, behavioral interactions during Phase I, and several performance parameters during Phase III. The transfer of performance between dyads was assessed across the two conditions.

The results demonstrated that a transfer of performance did occur in five of the six dyadic pairings. The animal identified as the winner in Phase I also was identified as the winner in Phase III among all dyads except between Einstein and Vern. Behavioral interactions observed during Phase I did not support the outcome of the competitive testing as previous research would support.

These findings illustrate that the computer paradigm is valuable in studying the behavior of animals during competitive interactions. It promotes the evaluation of the expression of competitive behavior in animals without the need for face-to-face matches and the confound of social hierarchies.

Alternative methods are discussed which may facilitate future research in this area. The results are discussed in terms of previous findings and the implications for future research.
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CHAPTER ONE

Introduction

In an effort to gain further understanding of the components of competitive feeding interactions in rhesus monkeys, the following study was conducted. Typically, the concept of competition has been examined within the context of social dominance relationships within a particular primate colony. Therefore, the concepts of competition and dominance have been so closely related that previous studies have been laden with equivocal results and misconceptions about the usefulness of the concept of dominance (Bernstein, 1981). The present study offers an alternate method for clarifying how factors of competition influence social behaviors, specifically, the acquisition of food. The purpose of this study was to compare behavioral or face-to-face competition with isolated competition within the same pairs of animals. A summary of studies in the area of social dominance and competition are described below along with the complexities of the issues associated with studying these concepts.

Social Dominance

The concept of social dominance was introduced as a description of the social organization of domestic fowl by the Norwegian naturalist Schjelderup-Ebbe in 1922 (as cited...
in Syme, 1974). Many studies and definitions of dominance refer to Schjelderup-Ebbe's now classic studies of peck order. His studies demonstrated that strange hens placed together in an enclosure fight by pecking each other until a straight-line linear hierarchy is established. Furthermore, the author noted that the aggression exhibited between any two animals was unidirectional. The animals could be clearly ranked according to their ability to peck others - the A (alpha) chick can peck all others, more than it is pecked itself, the B chick can peck all but the alpha, etc. Schjelderup-Ebbe generalized his findings to a theory of despotism as the fundamental structure of the social universe (Fedigan, 1982). One may or may not accept his generalizations. In any case, a peck order definition of dominance implies that animals organize themselves according to their ability to physically defeat or intimidate others in conflicts (Fedigan, 1982; Syme, 1974).

The concept of social dominance became increasingly popular to the extent it has been applied as a subject of study to nearly all vertebrates. More recently, it has been generalized further to include not only fish but invertebrates as well (Milinski, 1984). According to Richards (1974) the concept of social dominance has now become an explanatory concept widely used in studies of nonhuman primates. However, from the presentation of the study of animals' social orders described below, it will be
shown that the concepts are not as straightforward as they first appeared. Initially, it should be noted that the definitions have been as variable as the methods employed to measure these social phenomena. Attempts to measure dominance have included studies of priority to incentives (e.g. food: Belzung and Anderson, 1986; water: Boelkins, 1967; DeWaal, 1986), agonistic behaviors (e.g. Duetsch and Lee, 1991), approach/retreat and avoidance behavior (e.g. Bernstein and Sharpe, 1966), reproductive success (e.g. Deutsch and Lee, 1991), grooming behavior (e.g. Bernstein, 1970), and mounting behavior (e.g. Bernstein, 1970).

The concept of dominance is used in the behavioral and biological sciences to describe outcomes observed in a variety of interactions between animals. As well as from overt disputes, something can be learned about a dominance relationship between members of a social group because they do not enter into overt disputes when expected. If an important commodity such as food, water, or sexual partners is limited, it is expected that individual group members will compete for these. If, instead of fighting over the limited resource, one individual takes and uses it first, while others wait and may or may not have a turn at all, we infer that the "taker" did so because it is dominant. If challenged by the other animals it could win. However, it is not necessary to prove so in each instance. There are of course, always a number of other reasons why one individual
should have the first turn at or access to a resource (Fedigan, 1982). Further, as Fedigan (1982) indicates, there is an oversimplification of the phenomena categorized together as dominance, as well as an overestimation of the importance of physical coercion in day-to-day primate life.

Several sources offer a myriad of views of what this term "dominance" really signifies. First, according to the dictionary, dominance is defined as the ability to rule, control, or to influence others. McKenna (1982) identified the term as "referring to relational status or social rank of an animal as determined by its ability to compete successfully for goals with others" (p. 105). These contested goals might include attempts to gain access to physical resources such as food items. Contested goals might also involve attempts to obtain social resources such as access to mates or to establish proximity with certain group members in order to groom or to be groomed (McKenna, 1982). McKenna also is quick to note the common theme of this controversy; the criteria used to define dominance are suspect because various dominance measures do not correlate well with each other. Specifically, those individuals who consistently win agonistic contests are not necessarily the ones who receive more appeasement, more grooming, or who mount others more frequently. Kummer (1971) contends that dominance is a form of social control. Altmann (1981) holds a more extreme position stating that dominance relationships
are an invention, not a discovery. Further, he states that "dominance relationships are an epiphenomenon of agonistic interactions and as such they have causes but not consequences" (Altmann, 1981, p. 431). The following discussion will offer an overview of the nature of the research regarding social interactions, specifically dominance and an indication of the problems associated with the concept and methodologies frequently used to study it.

One may observe that in a social group of nonhuman primates, the animals may avoid a situation because of threatening behaviors emitted by another group member. Two primary factors may be operative in this situation: Individual recognition and rank relevant communication. Murphy, Miller and Mirsky (1955) separated these two factors when they trained monkeys to avoid shock using another monkey as a conditioned stimulus. The trained monkeys did not generalize their responses to all monkeys. That is, the animals went into the shock avoidance routine only when they saw the individual they learned to associate with shock. Thus, Murphy, et al. (1955) demonstrated in this case, that monkeys can learn on the basis of individual recognition. It may be impossible though, to exclude the possibility of extreme subtle communicative signals or gestures on the part of approaching higher ranking animals in a freely interacting group.
Further experimentation by Maroney and Leary (1957) however, revealed that submission could not be conditioned in a group of young rhesus monkeys. Maroney and Leary ranked ten young rhesus monkeys and then subjected them to trials with two "dominant conditioned animals". The young monkeys were highly submissive in the presence of these "dominant" monkeys, but their relationship with original members of the group remained unchanged. That is, they did not generalize their submissive behavior to other animals.

These studies demonstrate that to some extent, learning plays a crucial role in the development of social concepts in nonhuman primates. It is useful to consider these learning processes that are involved in forming dominance relationships under a variety of conditions: Those that occur during an animal's previous social experiences that it brings with it into a social situation and the learning that occurs during the establishment of relations between two animals. According to Rowell (1974) the learning process can be described in stages. The first essential step of the learning process is the ability to distinguish between individuals which usually takes place in the first week of life for a monkey. A monkey can distinguish at least its own mother from other adult females by the time it starts to leave her (early in the second week). The learning continues such that it includes the ability of the monkey to recognize its own species, sex differences, and age. These
recognition capacities seem to be innate since infant rhesus monkeys reared in isolation, with no previous social experiences, prefer their own species, and adult females over adult males. Additionally, Mason (1961) examined the dominance relationships in monkeys reared in isolation. These animals failed to demonstrate stable dominance relations. Reversals in dominance from one session to the next were quite frequent within these animals. It is the individual recognition of each member of the group by each other member that is the basis of a hierarchical organization. This demonstrated that a particular hierarchical relationship must be learned whether the predicted response itself is learned or not (Rowell, 1974).

There is little doubt that learning plays an important role in the social profile of a group of nonhuman primates. However, previous assessments of the profile have offered more discrepancies and confusion than useful information with respect to predicting social organization among nonhuman primates.

Historically there has been a distinction between two conceptual levels in the scientific study of dominance: A focus on asymmetrical relationships between two individuals (at the dyadic level) and the second had been a focus on the study of dominance in an entire group (hierarchy at the social level) (Fedigan, 1982). Dominance has been measured through studying the outcome of conflicts and/or patterns of
conflict avoidance at either of these levels. When individuals of a group come into conflict with one another, the interactions involved are referred to as agonism. If one individual of this interaction clearly physically defeats another, or by some criterion appears to "win" a dispute, the first individual is said to be dominant in that situation (Bernstein, 1981; Fedigan, 1982; Rowell, 1974). If "some individual consistently wins in this type of dispute, it can be said to be dominant over the other in that type of situation" (Fedigan, 1982, p. 92). Further, if it always wins disputes of any kind, it could be said to be first ranking, most dominant, or the "Alpha" individual. This measurement is based on social interactions in which fights occur and the observer can clearly decide who has won and who has lost.

An interest in the functional benefits of being dominant led researchers to define and measure dominance as expressed through "priority of access to incentives" which measures an animal's precedence over others in using desired and/or needed resources such as food, water, sleeping space, or sexual partners. Suppose the desired objects are limited and not everyone of the group can use them at the same time. Those who have first access to them are said to be dominant. One can immediately see some problems with this logic; the "power" over others, inherent in this definition of dominance is the ability to "go first", which may or may not
be the same as the ability to physically defeat others (Fedigan, 1982).

The method of priority of access to incentives was developed after observing that in some species, approach-retreat interactions did not occur often enough which led some researchers to believe that there is not a dominance hierarchy at all in these species. Others were not satisfied with this notion and developed the priority of access to incentives as a method in which animals are placed in an artificially created situation with limited food or water, for example, such that they must compete in order to acquire access to the limited resource. These tests are almost always conducted between pairs of animals.

Syme (1974) has referred to the "priority of access" definition of dominance as describing "competitive rank orders" whereas, "peck order" definitions describe "aggressive rank orders". Some researchers have argued that competitive rank orders function to reduce agonistic interactions and serve to allocate resources (Fedigan, 1982; Syme, 1974). Rowell (1974), however, has rejected this notion as she asserted that rank orders are only evident because of high rates of agonistic interactions in the first place.

One may observe that the words dominance, rank, status, and hierarchy often are used interchangeably, when in fact, they have different meanings. Fedigan (1982) explained the
differing components of each of these terms. The word 'dominance' can take on different operational definitions according to how it is measured. Basically, it refers to some form of power over others established through intimidation. Rank describes one's relative position in a series. For example, an individual can be ranked according to a myriad of criteria, such as size, age, etc. Dominance rank, then, refers to the relative amount of power over others in conflicts and conflict avoidance which an animal can exhibit. Status is a more general term meaning a state, condition, or position, which is not always a relative position in a ranked order. Thus, an individual monkey's status could be healthy, old, or pregnant, none of which are direct statements synonymous with dominance rank. Finally, the term hierarchy refers to a group of things which are arranged in order of rank or grade according to some value system or set of criteria; and a linear dominance hierarchy defines a straight line rank ordering of animals drawn up by the researcher according to their relative abilities to intimidate each other and win conflicts or use resources first.

Most species of primates seldom engage in actual physical fights (e.g., Strier, 1991). Instead, they more frequently exhibit behavioral signals which may serve to threaten physical contact and/or may use signals to indicate they will submit should there be physical contact. Any
actual fighting is circumvented. This is probably one of
the reasons many studies have shown that physical prowess is
not a fundamental determinant of dominance rank in
primates. Because a great deal more of primate agonistic
behavior consists of threats and submissive behavior than of
physical confrontation, primatologists often have turned to
the direction of agonistic signals as measurements of
dominance (Bernstein, 1981; Fedigan, 1982). As a result,
animals may be ranked according to how many and to whom else
in their social group they direct threats or from whom they
receive threats. One factor makes this type of assessment
difficult. It is not uncommon that individual primates
threaten others in their group who respond by either
ignoring them or threatening them in return. Under these
circumstances, it may be difficult to evaluate a relative
dominance rank. Bernstein (1970) found that the frequency
of threatening signals or the amount of aggression emitted
by an animal is not a very good indicator of dominance rank.

There has been some suggestion that the response to a
threat tells more about dominance relationships and that
only submissive signals are clear indices of subordinance.
Accordingly, Rowell (1974) has advocated the use of a
subordinance hierarchy based on the ranking of animals
according to whom they direct submissive signals which would
then result in the whole group ordered into a subordinance
hierarchy.
In either case, the assessment method of direction of agonistic interactions is based on the assumption that animals may be ranked according to who will move away or avoid an interaction. A common example occurs when one group member approaches another who is grooming, eating, etc. and the approached individual hurries away before any overt exchange of signals occurs. This form of approach-response interaction is termed supplantation or avoidance depending on the decision of the researcher as to whether the surrender of space or goods was forced or voluntary, respectively. These types of situations are difficult to declare as clear evidence of dominance or subordinance. If an individual avoids an impending interaction, for example, one cannot always assume the avoidance is motivated by fear or subordinant ranking, or the recognition of the approacher's higher dominance rank. An alternative explanation may involve simply a desire to avoid the social interaction at the time. Furthermore, one can not always assume the approaching individual intends to intimidate because what an approaching animal does after arriving often indicates its intention to join the grooming group or become involved in other social interactions (Fedigan, 1982). This aspect of the difficulty in measuring social dominance demonstrates just how subtle dominance relationships in primate groups can be.
Competition and Dominance

The relationship between competition and dominance is an important one to consider. Not uncommon is the notion that the outcome of a competitive situation is a dominance hierarchy. Competition arises when two or more individuals actively demand a common, limited resource (e.g. food, water, sexual partners). Competitive situations have often been used to study primate social relationships. Thus, members of a social group can be ranked in terms of their ability to win or succeed in the competitive situation by using the priority of access method described earlier (Bernstein, 1981; Brennan and Anderson, 1988; Rowell, 1974). The outcome of this assessment has been identified as a dominance hierarchy. Boelkins (1967) attempted to establish dominance hierarchies in a group of macaques (Macaca speciosa) based on an index of access to an incentive situation, in this case, water. Ten animals were tested in a group and placed on an 24-30 hour water deprivation schedule prior to each dominance test. The duration of each drink taken by a subject was recorded. Elapsed times were arranged from shortest to longest which provided a hierarchical ranking of each animal corresponding to its elapsed time rank. From the data collected, Boelkins (1967) concluded that "monkeys established and maintained stable dominance hierarchies" (p. 318).
Richards (1974) also attempted to assess a dominance hierarchy in a group of rhesus macaques using priority to food incentives. Richards was careful to identify that in assessing dominance using a priority-to-incentives method one must use some cautionary assessment techniques. That is, provisions must be made for the bold juvenile who rushes up, snatches the food and runs away. This problem was overcome by only ranking those individuals who stayed at the pile to eat; and by not ranking young individuals. Richards defined young individuals as those less than three years of age. This procedure was recommended due to the fact the young individuals have ranks which are dependent upon the rank of their mother, for example. Richards found great differences between the feeding behaviors of high and low ranking animals.

Further experimentation by Richards (1974) was focused on the study of social relationships based on priority to drink from a milk bottle. One milk bottle was placed at the front of the animals' pen following a milk deprivation period. The order in which individuals came to drink from the bottle spout was recorded during a 30-minute observation period. This test resulted in consistent rankings of the animals in 10 out of 12 cases. Richards asserted that this test was more competitive than the food situation because the food pile could be shared by more than one individual simultaneously whereas, the milk bottle spout could not. In
the food test, low ranking individuals frequently would approach the food pile; they sometimes would not approach the milk spout, however. In order to drink from the spout, the animals had to look away from the rest of the group, placing the drinker in a vulnerable position.

A major drawback to this assessment approach includes the fact that several factors may influence which of the two test animals will achieve access to the incentive (e.g. proximity to the source). These factors are believed to obscure the true or "basic" dominance which is being tested. Furthermore, dominance rank may vary with the social context (Bernstein, 1970; 1981; Hinde, 1987; Richards, 1974; Syme, 1974). A monkey, for example, will usually avoid taking food from the infant of a dominant female if the mother is present. If the mother is absent, though, the test monkey may treat the infant as though it had the mother's rank or conversely, the test monkey may attempt to dominate the infant. How is such an interaction assessed? These interactions will be variable and make little sense without knowledge of the social context. Even so, when two monkeys are taken from their group and placed alone, a third's influence may be significant although not apparent.

Some researchers attempt to avoid problems of social history by giving food tests to pairs of monkeys who are strangers to each other. In this case, the two monkeys must be of equal size, sex, health, and age in order to control
for such effects. In addition, they must be introduced to the strange cage at the same time so neither is more familiar with the surroundings. The food must be dropped exactly between them so proximity is not mistaken for priority of access (Fedigan, 1982; Syme, 1974). Even with such precautions observed, one cannot be confident that an underlying unitary attribute of an individual primate or social hierarchy is revealed. It could be said that food test dominance could be defined as testing that which food tests measure. "It is a self-limited finding of unknown value outside of the context in which it was tested" (Fedigan, 1982, p. 97). The reason being that if dominance relationships do exist, they do not exist in a social vacuum; rather, as Fedigan (1982) asserts, the relationships are closely associated with many of the factors considered to be noise or confounding variables and eliminated by other experiments. Therefore, what is being assessed is not a dominance social relationship at all. The social relationship is being altered or masked by the manipulations. In fact, Rowell (1974) contends that instead of the experimental trials attempting to demonstrate a dominance relationship between monkeys, they actually caused it.

Bernstein (1970) questioned the attribute of dominance as it related to grooming. What is the influence of dominance status relationships on grooming? What is the
function of grooming behavior? After studying several taxa of primates over long periods of time, it was determined that little consistence was observed in grooming roles from month to month in the mangabey, green monkey or Celebes groups. Bernstein (1970) noted that grooming is essentially a reciprocal response pattern and one in which roles are exchanged frequently. One of the few cases in which the grooming animal seldom if ever received grooming in return was identified in the case of grooming of young infants.

Furthermore, Bernstein (1970) insists that "none of these response relationships should be considered a necessary component of all primate societies, or as necessarily predictive of other social relationships" (p. 104). Essentially different mechanisms may be at the root of such behavioral responses that arise from agonistic interactions, grooming patterns and mounting episodes. It is the observer's responsibility to have an acute awareness that a variety of factors influence any animal's social group which may or may not be the same for all animals of that taxa.

One is left with several possibilities as to what dominance relationships signify: 1.) real underlying structures even when not ordinarily apparent, 2.) one of the potential responses of primate groups to extreme conditions and therefore of interest to those attempting to understand social behavior, or 3.) artificial phenomena
produced by the contingencies of the experiment. Of primary importance is to be aware that the best use of the dominance concept is to restrict it to its proper domain of specified forms of power, control, or influence, in specified social interactions. Dominance relationships never have an absolute unitary quality or universally predictive value and explanatory power in primate societies. The frequency with which researchers are unable to find correlations among several dominance assessments clearly illustrates that it is incorrect to think of dominance rank as a unitary characteristic possessed by an individual and incorrect to think of dominance relationships in dyads and dominance hierarchies, as a single phenomenon generalizable and applicable to all social interactions.

Because of the widespread misconceptions regarding what dominance is, Fedigan (1982) offers a rather complete explication discussing what dominance is not. The following provides a summary of her conclusions. Dominance is not determined primarily by the physical attribute of size and strength. Other factors like social learning may be more related to the countless examples of individuals who are either old or physically weak and still dominant over other animals of the group. Secondly, dominance is not determined primarily by the amount of aggressiveness. Typically, aggression is measured by frequency of threatening behaviors or frequency of fights. The animals exhibiting the most
frequent incidents of aggression are not necessarily the same ones who may win fights or have priority of access to incentives. It is a mistake or oversimplification to assume that the amount of aggression is the major cause of dominance rank in the first place. The direction of causality may in fact, be the reverse. Rowell (1974) and Bernstein (1976) have suggested that higher ranking animals exhibit more skills in managing patterns of aggression. Therefore, although the findings may be an oversimplification, one may not generalize about the causation or even correlation between features of dominance rank and aggression.

Fedigan (1982) continued to state that dominance is not a permanent trait possessed by an individual over time. These rankings change over the years. Various forms of dominance that we recognize are actually inferences about aspects of relationships between individuals and therefore, do not reside within the individual. As social contexts change, so do social relationships. Because dominance describes the relationship between individuals or a network of social relationships, whatever genetic influences may be hypothesized to exist probably are very general and indirect (Lee, 1983). The focus of research on dominance relationships has resided within male primates. Studies have shown that male primates are more likely to be mobile and exchange between groups (Prud' Homme, 1991). Due to the
fact that dominance is dependent upon social context, males, therefore, are more likely to have unstable rank relationships (Fedigan, 1982). It is a misconception to generalize that dominance is more characteristic of males than females.

Rationale for Present Study

This concept of dominance has been overrated as a general governing principle of social behavior. It must be approached with caution, to determine if any utility can be derived from the myriad of perspectives about the nature of dominance. Plagued with conflicting information and misunderstandings, several researchers persist in the study of social organizations and the representation of dominance in primate societies, as it is a useful concept in understanding primate interactions. Some individuals of an animal colony do win certain conflicts and do go first in certain situations. The ability to do so successfully is a social reality and probably a sophisticated social skill. What value then, can be derived from such a nebulous concept? The availability of resources in an organism's environment can influence the existing social organization. Limited availability of resources, for example, may result in increased competition for those resources. It is this type of scenario in which the concept of dominance may be useful. But there must be limitations to its use. That is, this concept of dominance may be more useful as an
"intervening variable" for describing or explaining interactions between individuals (Hinde, 1978; Lee, 1983; Richards, 1974). In this case, like any intervening variable, dominance would be treated as a characteristic or postulated characteristic, which has explanatory power (Bernstein, 1980; Fedigan, 1982). The predictive behavioral measure may be the competitive performance of the animals in the particular situation. Competition can be assessed directly and objectively.

It has been postulated that in a competitive situation any behavioral choices made by the animal would reflect potential costs and benefits of competing rather than responses predetermined by a given social status (Brennan and Anderson, 1988). For instance, if one perceives a social encounter, perhaps involving competition over one of several available food patches, as a potential danger to one's self or one's offspring, the cost of competition would outweigh the benefits that might be gained. Wilson (1975) pointed out that dominance hierarchies represent one outcome of contest competition in which two or more individuals actively demand a common, limited resource. (Notice that the outcome is a dominance hierarchy; it is not a predictor of any response patterns observed.) Different resource patterns lead to different effects on the social interactions. Where resource competition is low, one may not see overt aggression. Time spent engaging in aggressive
actions will be time not spent on feeding and/or mating. Dominance hierarchies are most likely to form where for example, a food patch's resources are limited (Deutsch and Lee, 1988; Jones, 1981). Researchers who have supported this notion have conducted studies in which they assessed variables hypothesized to influence social processes in feeding situations (Boccia, Laudenslager and Reite, 1988; Brennan and Anderson, 1988; Deutsch and Lee, 1991). These variables have included food distribution (Boccia, et al., 1988), risk feeding (Brennan and Anderson, 1988) and location of feeding site (Deutsch and Lee, 1991). These researchers have been partially successful in integrating the use of dominance and competition. However, several of the aforementioned confounding variables cannot be controlled which may include an animal's learned associations that its competitor is the daughter/son of a very high ranking female, and/or an animal's variable capacity to compete given particular social situations.

Nevertheless, competition is an important factor and a reality in day-to-day primate life. Based on this fact, each individual of a social organization must possess some level of competitive ability in order to survive and reproduce in its environment. The extent to which this level of competitiveness is expressed by individuals is controlled by the social context in which the animal resides. Several of the studies previously mentioned have
demonstrated that the social context is a controlling factor in the expression of dominance, for example (Bernstein, 1970; 1981; Hinde, 1978; Rowell, 1974). Social status and competition are virtually inseparable in any situation in which animals are being studied in a group context. As a result of this close interaction between these two concepts, it is difficult to assert that one does not influence the other. Brennan and Anderson (1988) conclude that "the social class to which a rhesus monkey belongs is an important determinant of the individual's behavior in competitive situations" (p. 359). However, if these factors can be made independent of each other within an experimental paradigm, then the effects of competition, for example, on aspects of foraging can be studied systematically.

The present study offers this alternative method to conducting research in the area of primate social organizations by utilizing a video-task paradigm which will be explained subsequent to a presentation of other research using this same paradigm. Washburn, Hopkins and Rumbaugh (1989) examined the effects of stimulus movement on learning, transfer, matching and short-term memory performance utilizing the video-task paradigm in which animals respond to computer-generated images using a joystick. It has been well established that rhesus monkeys can operate a joystick controlling a computer generated
image on a computer monitor. In another study Washburn, et al. (1990) assessed the effects of competition on performance using this same paradigm with rhesus monkeys. The task required two animals working independently, to shoot at the same target on a computer screen. In this situation, the influence of social organizational variables was absent. It was not examined how the social context influenced the results. That is, the question remains as to how the presence of another animal will affect the way in which an animal will respond in a given competitive situation.

In the present study, however, these variables were the focus. The research question revolved around the early theses presented regarding the level of competitive ability that is expressed by animals within and without a physical encounter with another animal. As previously indicated, the video-task paradigm was employed but in this case, the goal was to determine if a competitive social situation can be introduced using the computer. To meet that end, the experiment was designed using four male rhesus monkeys as subjects. The subjects in this study were males to control for the behavioral changes (including competitiveness for food) that have been observed to be associated with the female's periods of estrus (Lindburg, 1971; Mitchell, 1979).
Phase I (behavioral competition) assessed the monkeys' performance in a dyadic competitive situation with another animal in a single common cage. The animals competed for a limited food source presented on repeated trials. It was not the goal of this phase of the study to demonstrate the existence of dominance hierarchy, alter an existing social structure, or demonstrate the expression of agonism. Using the concept of dyadic competition in a food test paradigm assessed the animals' ability to compete in a foraging situation. It was expected that one animal would be the winner of the dyad more often than its partner.

The second and third phases of the experiment introduced competition for food using a computer task paradigm in which the animals controlled movement on the computer. After a series of shaping procedures (Phase II) to reduce the possibility of performance effects, the animals worked on a computer task in Phase III (computer competition) independently but in competition with another monkey. This task was a computer representation of the dyadic competitive situation presented to the animals in Phase I. The task required that a circular figure controlled by the monkey must make contact with a square figure on the screen in order to receive a food reward. Figure 1 is a sample representation of the screen configuration.
Figure 1.

Example Screen Configuration for Phase III

○ = Animal's figure

□ = Food object
The major difference in the simulation of Phase III and the behavioral test of Phase I is that the animals did not have visual contact with their competitor. Phase I required that they compete face-to-face with one another. In Phase III however, they were working in separate cages but each animal controlled a respective computer-generated figure on the monitor by joystick manipulation. In this case, positioning by the animals for competitive advantage in getting the food reward is done by controlling a figure on the computer screen.

As shown in Figure 1, the animal's starting figure position was located in one of the upper corners. In order to reach the prey object, the monkey manipulated the joystick to move their respective figure down the screen to make contact with the square object that represented food.

If competitiveness transfers across food gathering situations and is not exclusively determined by threats or physical contact, then it was hypothesized that the winner within each dyad of Phase I also would be the winner of the dyad in Phase III. Furthermore, it was expected that optimal performance in Phase III would be characterized by low overall time per reinforcement and a high frequency of wins by one animal within each of the dyads.

Several congruent aspects between the behavioral competition and the computer conditions exist. The attainment of the reward in each case was facilitated by
positioning oneself appropriately. In Phase I, the animal who received the reward had to position himself in such a way to reach the delivery bowl in the cage first. Similarly, in the computer simulation, the animal had to manipulate his figure down the screen to the door to be prepared for access to the prey object on the screen. Identical sets of dyads used in Phase I will be used in Phase III. Each animal had an equal opportunity to gain access to the food item to the extent that it is proficient in competitive situations.

However, the differences between the two conditions are apparent and must be recognized. In Phase 1, each animal had the ability to be in physical contact with its opponent. That physical representation was transferred into a computer interface in Phase 3. Each animal was exposed to the computer monitor to assess their own and the opponent's position relative to the food source. But the possibility of visual interactions (e.g. threats or stares) was absent.
Chapter Two

PHASE I

Method

Subjects. Subjects in this experiment were four 5 year old male rhesus monkeys (M. mulatta) identified by the names: Skeeter, Vern, Bud and Einstein. The animals were reared in social group housing and rotated periodically into separate cages (3 ft. x 4 ft. x 4 ft.) for testing purposes. The animals were housed in tower cages that accommodated two animals in the top and two in the bottom portion of the tower cage with each pair separated by a sliding door between the individual cages. These cages were arranged so that they could be converted into the testing chamber for the first phase of this experiment by opening the sliding door.

All subjects had previous shaping experience using the video game paradigm to forage for food items. None of the animals, however, had experience with the present task. The current study was conducted under conditions of an open economy in which the animals were maintained at 90% of their free-feeding weight. Ad libitum water was available in their home cages at all times. Throughout the experiment, animals were weighed at least once a week to monitor their weights. If any changes in weight were observed, accommodation was made in their feeding regimen. Throughout
the experiment, the animals were fed approximately two hours after testing was completed.

Apparatus. The testing chambers were similar to each animal's home cage in that the sliding door separating each dyad was removed for the testing period. A data sheet was used to record behavioral interactions between the animals during the testing period [see Appendix A].

Procedure. Phase I was designed to assess the monkeys' performance in competition for food within a dyadic relationship. The animals were assigned to dyads. The combination of dyads was formed by utilizing each possible combination of animals from this group of animals. The combinations were arranged such that all animals were tested daily throughout the experimental phases [see Appendix B].

Initially, the animals of a dyad were placed individually in the single cage that served as the testing chamber. Prior to the initiation of this test phase, the animals were shaped to the delivery of food pieces (pieces of KIX cereal) in a food dish that was attached to the side of their cage. This procedure continued for four days.

Following the completion of this preparation, the testing phase began. At the start of each test session, the sliding door that separated a dyad was opened allowing the animals to have full visual and physical contact with one another. For a period of 5 minutes following physical exposure, behavioral interactions were recorded by three
observers located in the room. The interrater reliability for these behavioral observations averaged 95 percent.

During this pre-trial period, the following behavioral observations of the dyadic interactions and animal's individual behavior were recorded: Open-mouth threat, displacement, successful or unsuccessful attempts to grab other monkey, fear grin or screech, slap, bite, submissive posturing, crouch to back of cage, and/or hair pulling [see Appendix A]. The direction of the encounter (who did what to whom) was also recorded.

Following this 5 minute observational period, both animals were directed to one side of the test cage and the sliding door was closed. At this point, one piece of the cereal was placed in the food cup attached to the opposite cage on the other side of the door. Fifteen seconds elapsed and Trial 1 began. The sliding door was opened and three observers recorded any behavioral interactions between the animals in addition to the "winner" of the trial. The trial concluded after an animal obtained the food item. At this point, the door was shut confining the animals to one side of the testing chamber. A 15 second ITI began. During the ITI, food was delivered to the opposite cage food cup. Following the ITI, Trial 2 began. This procedure continued for 20 trials. Two dyads were tested for 20 trials in each daily testing session. Each unique dyad was tested twice with the stipulation that identical dyads were not tested on
two consecutive days. Phase I required seven days due to a fight that occurred between Skeeter and Einstein upon pairing them for the second time for testing which required that the pairing be repeated on a subsequent day.

The following behavioral observations were recorded: 1.) the animal who attained the food item, 2.) the number of trials each animal attained the food, 3.) the method of food attainment (for example, did the animal "snatch" the food from the dish?), and 4.) the latency of reward acquisition. The interrater reliability for these observations averaged 99 percent. Further observations were recorded including those components of agonistic or submissive behaviors previously identified and the directionality of those behaviors. Interrater reliability of these measures averaged 98 percent.
CHAPTER THREE

PHASE II

Method

Subjects. Those animals that participated in Phase I participated in this phase also.

Apparatus. The testing chamber consisted of the monkeys' home cage (3 ft. x 3 ft. x 4 ft.) with a removable cart containing two computer monitors and joysticks positioned side by side to facilitate the testing of two animals simultaneously. One feeder is positioned on each side of the cart. A camera apparatus was connected to the front panel of the cart. The monitors were positioned approximately 15 cm from the face of the animal's cage. The joysticks were centered beneath the monitor and protrude out from each apparatus approximately 8 cm into the home cage where the monkey had access to it when sitting near the front of the cage. Each feeder dispensed a single food piece into a bowl in the animal's cage.

The task was programmed on a Zenith Data Systems 286 ZCM 1492-1 computer in programming language 'C'. The computer controlled the feeder to dispense reinforcement and recorded data onto floppy disks for permanent storage. Monkeys were observed via a camera installed on the cart and pointed at a split mirror over the testing chamber.
Procedure

Shaping I. The animals were transferred to individual cages as described above which were suited for playing the computer game. They were housed in these cages for the duration of the experiment. Following the transfer of the animals, an adaptation period of two days expired before the shaping began.

The purpose of Phase II was to shape the animals to move a ball-shaped figure using their joystick to make contact with a square object representing food on the screen and assess each animal's computer foraging skills. During this phase of the procedure a basic program was used in shaping the animals to manipulate the joystick to move a ball figure specific to them and to make contact with the object representing food. Each monkey was assigned a differentially colored figure (Bud = black; Vern = white; Einstein = green; Skeeter = orange) which only they used throughout the entire experiment. Figure 1 illustrates a sample configuration of the computer screen for one trial.

The square figure at the bottom of the screen represents the food object (17 x 17 pixels). In the upper right corner is the monkey's figure (16 x 16 pixels). The barrier positioned in front of the food object remained open for the duration of this shaping phase. The diagonal side
barriers served as walls through which the ball could not pass.

For the first 15 trials of this shaping procedure, the monkey's figure was located successive distances away from the food object on the screen. In subsequent trials the position of the monkey's figure varied quasi-randomly between the left and right upper corners from the start of the session. That is, the monkey's figure appeared on both the left and the right sides of the configuration with the stipulation that the ball could not appear on one side more than three consecutive trials.

The beginning of this shaping session and Trial 1 was identified by the onset of the screen configuration. The food object appeared in its designated location (i.e., always in the bottom center of the screen) simultaneously with the screen onset and remained available until the ball made contact with it. When the ball overlapped with the square object, the computer dispensed a reinforcement (same as the reinforcement used in Phase I). Reset of the screen did not occur until the monkey's figure reached and made contact with the square object. When this occurred, a 15 second ITI began in which the monkey saw only a blank screen. Following this ITI, the screen reset to the next configuration (trial). Throughout this shaping session, the food appeared simultaneously with the beginning of each
trial and remained available until the monkey's ball reached it.

The experimenter also was able to control reinforcement. For example, if the animal was manipulating the ball to the square object but having some difficulty in attaining the contingency concepts, a reinforcer was delivered. Each Shaping I session included up to 20 trials depending upon the animal's performance. That is, a session was terminated if an animal failed to progress through the 20 trials in less than 60 minutes. This session was concluded after nine days.

Measures recorded included the time it took for the ball figure to reach the food item during each trial, the number of food items attained through hand reinforcement and contact with the square object for the entire session, and the (x,y) position of the monkeys' figure every second during each trial of the sessions. The criterion used for advancing an animal to Shaping II was that each animal experience four sessions consisting of the maximum number of trials (20).

**Shaping II.** The purpose of this shaping procedure was to introduce the animals to a blockade in front of the food object on the screen. This version of the shaping procedure was identical in terms of the food object availability and criteria requirements to those that were previously identified in Shaping I. These sessions also consisted of
20 trials. The screen configuration seen by the monkey was somewhat different in this session, however. During this shaping procedure, a barrier (which will be referred to as the "door" in the future) was placed in front of the food object. The figure could not pass through to the square as long as the door remained above the square. The contingency to obtain reinforcement for this shaping procedure were identical to Shaping I. The difference was the presence of the door for a period of four seconds at the onset of each trial (no animal during Shaping I was able to reach the square in this amount of time). Shaping II lasted 11 days. The measures which were recorded were identical to those in Shaping I.

**Shaping III.** This shaping program incorporated a delay in the disappearance of the door above the square. Such a manipulation facilitated training the animals to wait at the door and then to pass through once the door was open and reach the food object. This fixed delay was determined based on each animal's median time per reinforcer as demonstrated in the last three days of the previous shaping procedure. If, for example, the longest time an animal required to reach the food object at the end of Shaping II was 40 seconds, that time was used as the delay for that animal. After this interval elapsed, the square was then available for the animal to contact. This delay was decreased concordant with a decrease in the animal's latency to reach
the door. The time used for the delay in the door for all animals was 20 seconds by the final days of this shaping procedure. The next trial began with the resetting of the screen.

Identical criteria to that which were used in Shaping II were employed in this procedure also. A session was terminated if an animal failed to progress through a session of 20 trials in less 60 minutes. The duration of this procedure was 18 days. The measures that were recorded were identical to those recorded in Shaping II.

**Shaping IV.** The purpose of this procedure was to introduce the animal to the novel appearance on the screen of a second ball. A computer generated and controlled ball was placed on the opposite side of the screen to the monkey controlled ball. The color of the computer ball varied between the other figures' colors that were assigned to other animals. That is, the monkey playing was in control of the same color figure that they had been controlling in the last several phases except that they were receiving exposure to the other color differentiated figures.

This procedure consisted of shaping sessions of 20 trials in which each animal was presented each of the other three colored figures. It was necessary that the animals experience the movement of another figure. Therefore, the computer controlled ball moved about the screen in a fixed
box pattern around its original starting position for each trial.

The contingencies described in Shaping III were consistent in this phase with the following modification. If the monkey's figure made contact with the computer's, the start positions of each figure were reset and the same trial continued. As in previous phases, a session was terminated if an animal failed to progress through 20 trials in less than 60 minutes.

Measures recorded during this procedure were identical to those previously identified in Shaping II with the addition of recording the number of contacts the monkey's ball made with the computer figure. In order for an animal to complete this last phase of shaping, each one had to attain a minimum of 16 reinforcements for two consecutive sessions without receiving any hand reinforcement from the experimenter. This procedure lasted for 13 days.
CHAPTER FOUR

PHASE III

Method

Subjects. The subjects in this phase included those animals who participated in the previous phases. They were tested in the cages under similar conditions described earlier.

Apparatus. The testing chamber for each animal was identical to that described in Phase II. In this experiment, two animals were competing for one food source. The animals' separate home cages were used for testing.

Procedure. In this phase, two monkeys competed against one another for food reward. Both monkeys saw identical screen configurations on their individual monitors. Each animal had access to their own joystick which they used to control their figure. The animals were competing using their figure to reach the square object on the screen which represented food.

The contingencies used (the duration of the fixed interval and consequence for hitting opponent's figure) were identical to those employed in the earlier shaping phases. Each testing session began with Trial 1 in which the funnel configuration (Figure 1) appeared on each animal's monitor with their ball figure on the top left or right and their opponent's ball on the opposite side. Each animal's goal was to reach the barrier at the bottom of the screen before
their opponent and contact the food object after the door opened. The time delay in the opening of the door remained at 20 seconds throughout this procedure. If an animal manipulated its figure to hit the opponent's, both figures were reset to their respective start positions and that same trial was continued.

Two dyads of animals were tested, each in one session of 20 trials per day for a period of five days. Testing of all six dyads for 100 trials per dyad required 15 days. Measures recorded in this experiment included the number of food items attained by each animal, each animal's figure (x,y) positions during each trial, and number of contacts the figures made with each other.
Chapter Five

Results

After 40 trials (two sessions) of face-to-face competition were conducted between each dyadic pairing in Phase I, the performance of each animal was assessed. The measure of competition for the purposes of this project was the percentage of trials won by each animal within the dyads. Figure 2 is a representation of the percentage of wins by each animal within dyads.

Figure 2. Percent of Wins Within Each Dyad for Phase 1

Note: E=Einstein, V=Vern, S=Skeeter, B=Bud
As shown in Figure 2, there is at least a 20% spread between the scores of the winner and loser within each dyad. The winners of each dyad are highlighted with a star next to their initial.

Behavioral interactions were observed between the dyads. Table 1 illustrates the behaviors that were observed during face-to-face competition.

Table 1

Behavioral Interactions Observed
Between Animals

<table>
<thead>
<tr>
<th>Dyad</th>
<th>I</th>
<th>R</th>
<th>Behavior</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>S\E</td>
<td>E</td>
<td>S</td>
<td>Submissive grin</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>E</td>
<td>Grabbing</td>
<td>1</td>
</tr>
<tr>
<td>S\B</td>
<td>B</td>
<td>S</td>
<td>Submissive grin</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>E</td>
<td>Grabbing</td>
<td>1</td>
</tr>
<tr>
<td>V\S</td>
<td>S</td>
<td>V</td>
<td>Biting</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: S=Skeeter, E=Einstein, B=Bud, V=Vern; I=Initiator of action and R=Recipient of action.

One additional behavior that was observed between the dyads was the mounting of one monkey by another. The most important aspect of this measure is who mounted whom. In this case, reversals occurred between all dyads. That is,
if Bud mounted Vern, Vern also mounted Bud. These measures were collected in the event that the frequency of wins and losses during face-to-face competition were not indicative of a clear winner. However, these measures were not necessary for such an analysis as can be seen from Figure 2 which illustrates clearly that one monkey won substantially more trials than it's partner during Phase I. Furthermore, in comparing the observational data with the competitive data, it is evident that there is an inconsistency between the outcome of the behavioral competition and the directionality of the observed interactions which will be discussed in greater detail in Chapter Six.

The basic measure of competition in the computer simulation of Phase III also was the percentage of trials won between dyadic pairings. Each of the six dyads experienced 100 trials of competition (five sessions). Figure 3 represents the percentage of trials won by each animal within dyads based on their figures' respective starting positions (left or right) on the computer screen. The animal who won the greatest percentage of trials was considered the winner of the dyad. The winners of each dyad are highlighted with a star next to their initial (differences in wins by position will be identified later).
Of the six dyads, four of the dyads demonstrated substantial differences in the number of wins and losses: Einstein and Vern, Skeeter and Einstein, Bud and Vern, Einstein and Bud. Two of the dyads did not demonstrate such differences: Skeeter/Bud and Vern/Skeeter showed only a difference of eight and 14 trials respectively.

Moreover, the transfer of competitive behavior across the two conditions can be assessed by comparing the results of Phase I and III. Table 2 identifies the number of trials won by each animal in Phase I and Phase III.
Table 2

Number of Trials Won by Each Animal Within Dyads for Phase I and Phase III

<table>
<thead>
<tr>
<th>Dyads</th>
<th>Phase I</th>
<th>Trials %</th>
<th>Phase II</th>
<th>Trials %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeeter</td>
<td>27 (68)</td>
<td></td>
<td>100 (100)</td>
<td></td>
</tr>
<tr>
<td>Einstein</td>
<td>13 (32)</td>
<td></td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Vern</td>
<td>30 (75)</td>
<td></td>
<td>89 (89)</td>
<td></td>
</tr>
<tr>
<td>Bud</td>
<td>10 (25)</td>
<td></td>
<td>11 (11)</td>
<td></td>
</tr>
<tr>
<td>Einstein</td>
<td>24 (60)</td>
<td></td>
<td>95 (95)</td>
<td></td>
</tr>
<tr>
<td>Bud</td>
<td>16 (40)</td>
<td></td>
<td>5 (5)</td>
<td></td>
</tr>
<tr>
<td>Bud</td>
<td>26 (65)</td>
<td></td>
<td>54 (54)</td>
<td></td>
</tr>
<tr>
<td>Skeeter</td>
<td>14 (35)</td>
<td></td>
<td>46 (46)</td>
<td></td>
</tr>
<tr>
<td>Vern</td>
<td>25 (63)</td>
<td></td>
<td>57 (57)</td>
<td></td>
</tr>
<tr>
<td>Skeeter</td>
<td>15 (37)</td>
<td></td>
<td>43 (43)</td>
<td></td>
</tr>
<tr>
<td>Einstein</td>
<td>25 (63)</td>
<td></td>
<td>14 (14)</td>
<td></td>
</tr>
<tr>
<td>Vern</td>
<td>15 (37)</td>
<td></td>
<td>86 (86)</td>
<td></td>
</tr>
</tbody>
</table>
In comparing the outcome between the first three dyads listed in Table 2 (Skeeter/Einstein, Vern/Bud, Einstein/Bud), the winner of the respective pairs in Phase I also demonstrated the more competitive behavior in Phase III. That is, the winner of each of these three dyads in the behavioral situation was also the winner of that dyad in the computer mediated condition. Between Bud and Skeeter and Vern and Skeeter listed next in Table 2, these two dyads failed to show differences in their computer performance. However, the directionality of the competition between these dyads in Phase I and III is supportive of the hypothesis.

The one dyad that is an exception to the directional consistency is Einstein and Vern. Table 2 illustrates the results of competition between Einstein and Vern. Einstein won a substantial number of the trials against Vern during competition in Phase I. With respect to Phase III, there was a reversal in the winner of this dyad. As shown in the table, Vern won the majority of the trials against Einstein in the computer simulation.

Some evaluation of the Einstein's performance during shaping is necessary to provide an understanding of his performance during the computer mediated trials. Einstein was the only animal who required hand shaping in the last shaping program in order to play. On the fourth day of Shaping IV, he did not complete any trials. Hand shaping was initiated on Day 5. He received 21 hand reinforcers and
completed all 20 trials of that session. Hand shaping continued for six more days. Shaping IV continued for three additional days to assess his performance. His performance was inconsistent for those last three days and he did not reach the preestablished criterion levels.

Another way to illustrate performance during the last shaping procedure is to evaluate the median time per reinforcer for each animal. Figure 4 shows the median time per reinforcer during the last five days of Shaping IV for each animal by the start position of their figure.

Figure 4. Median Time per Reinforcer During Shape IV.
The median was chosen as most descriptive due to the wide range of variance in the population of times for each animal (range = 21-70 seconds). Given that the delay in the door for this procedure was 20 seconds, the shortest possible time per reinforcer was 21 seconds per reinforcer. All times are within a reasonable range of 15 seconds with the exception of Skeeter's. He showed an increased time when his figure's start position was in the upper right corner of the screen (70 sec.). However, he demonstrated a time per reinforcer from the left side which was equivalent to Vern's (25.5 sec.). Bud showed a slight increase in median time from the right (34.5 sec.), Vern demonstrated no bias from either start position, and Einstein showed only a slight increase in median time when his figure started on the left (39.5 sec.).

This bias in median time per reinforcer based on start position during Shaping IV was not evident in all animals during competition in Phase III. Figure 5 illustrates each animals' median time within dyadic pairings. As shown in this figure, the most notable change in median performance from Shaping IV is observed between Einstein and Bud. Einstein's time per reinforcer decreased while Bud's increased greatly, especially for the right start position.
Finally, there are two additional points worth highlighting with respect to these results. First, as shown in Figure 3, the only dyads that showed a bias to winning trials in which their figure started from the left were dyads between Skeeter and another animal. That is, this differential performance is apparent for Skeeter vs Bud and Skeeter vs Vern in which the majority of trials won, were won from the left side start position (81% and 92%)
respectively). Appendix C represents the percent of wins from the left and right start position by each animal within dyads across the five test sessions of Phase III. Lastly, Einstein, the animal who won only 14% of the trials against Vern and did not win any against Skeeter, played the game and won virtually all the trails when he played against Bud.
CHAPTER SIX
Discussion

The goal of this study was to produce a computer simulation that represented a behavioral dyadic competitive encounter between rhesus monkeys. Consider the hypothesis that the winner within each dyad of Phase I also would be the winner of that dyad in Phase III. This hypothesis was supported to some extent by five of the six dyads (Skeeter/Bud, Skeeter/Einstein, Bud/Vern, Vern/Skeeter, Einstein/Bud). The animals' similarity of competitive performance in the face-to-face and computer conditions demonstrates that the physical presence of the opponent may not be as important to competitive performance as other variables such as past experience or social history (Bercovitch, 1991). It was also expected that the winner between dyads would have demonstrated the lower median time per reinforcer. Because of some of the factors described below, the findings of this study are not supportive. However, Vern's performance was relatively stable throughout Phase III and he did come out the overall winner against each of the other animals.

As Brennan and Anderson (1988) suggest, the behavior of highly competitive monkeys may be invariant across the feeding situations. The present results demonstrate that competitive behavior across the two situations was relatively invariant. This finding supports the possible
use of computers to model competitive situations and has great potential to be used in studying the food-related behavior of monkeys across different feeding conditions.

One dyad did not perform consistently across the two competitive conditions. The winner of the dyad of Einstein and Vern was different for the behavioral and the computer competition. As previously stated, Einstein was the only animal who did not reach the criterion level of performance in Shaping IV to advance to the computer competition despite the simple requirements of the task. However, it was decided that he would be maintained in the experiment to proceed to the competition phase. This decision was based on the fact that his median time per reinforcer during the last five days of Shaping IV was acceptable (refer to Figure 4) and that anecdotally, when he manipulated the joystick toward the square, he did it with great accuracy. These observations led to the conclusion that he had demonstrated that he could perform the task given contingencies involved in attaining the reinforcers.

Einstein's performance during competition was demonstrative of the conclusions stated previously. He did not win against Vern or Skeeter. However, when he played against Bud, he did play and won 95% of those trials. The variable or variables that may have been operating to control his behavior in this dyad are not clear. One can speculate, however, that individual differences in
competitive behavior operated not only to promote Einstein to play the game but also to inhibit Bud from playing.

In considering the performance of Skeeter, it is evident that the animals with whom he competed (with the exception of Einstein) were "forced" to compete using a left start position bias. That is, Vern did not demonstrate this type of bias against Einstein or Bud based on start position or on median time per reinforcer. Nor did Einstein demonstrate this bias when playing Bud. However, when Skeeter was paired with another animal, the majority of trials won by either animal occurred when their respective figures started from the left side. Anecdotally, it was observed during Shaping IV that Skeeter was the only animal who showed more dramatic behaviors in manipulating the joystick under conditions in which his figure started from the right side of the screen.

There are alternate explanations which may account for the incomplete transfer of performance across the two competitive conditions by all six dyads. Alternative explanations may include differences in the animals' computer playing skills. Einstein may have performed differently had he reached the criterion level of performance. Further, Vern demonstrated the least amount of variation in median time per reinforcer across shaping and competition regardless of the dyad in which he participated. The other animals' performance fluctuated to some extent
between shaping and competition depending upon the dyad in which they competed. Additionally, Vern and Bud had participated in a previous experiment two years prior to this study in which they had considerable experience in under different conditions but using the video paradigm. The computer task used in this study was considered to be one of the most fundamentally facile tasks to which these animals have been exposed. However, Bud and Vern's previous computer experience may have contributed to some of the differences in performance observed between the animals during shaping and competition (e.g., start position bias, ease in movement of the joystick).

In this study, the animals were observed in dyads in which they competed for a limited resource. Social interactions between the dyads were recorded. The interactions that were systematically observed included submissive grins, grabbing, biting, and mounting as previously described. In terms of mounting behavior, it could not be used as an indicator of dominance or competition or control of one animal over another given that the interactions were reversed among each dyad. In considering the submissive grins observed, they do not correlate with the competitive interactions observed in Phase I. For example, Bud submissive grinned to Skeeter in Phase I but was the winner of the dyad in the competition of this Phase. Furthermore, Skeeter grabbed at Bud during the
same session. Behavioral models of competition would have predicted that the animal initiating a submissive grin, for example, would be less dominant than its partner and therefore demonstrate less competitive behavior in a situation. The findings in the current study do not support such a conclusion.

Upon the second pairing of Skeeter and Einstein, a fight occurred which lasted for only a few seconds and resulted in only minor scratches. The impact that this fight had upon the subsequent interactions of these two animals and the others is unclear. However, it does serve to highlight the fact that several authors previously have noted. That is, these behaviors cannot be used as absolute indicators or predictors of a dominance hierarchy (Bernstein, 1970; Fedigan, 1982; McKenna, 1982). Invariably, some reversal will occur between animals and any linear hierarchy established will not be valid in relationship to the behaviors assessed. Also, it is evident that in pursuing this line of research it becomes extremely valuable to have the advantage of using a computer interface in studying competition so that injuries of any kind between animals are prevented.

The role of the social interactions or relationships in this experiment are important to explore. It was stated early on that the social context in which an animal resides is extremely important in determining the behavioral
interactions with its conspecifics. The animals in the study were removed from their social housing. Thus, their social context changed with respect to their previous group housing experience. Bernstein and Gordon (1980) demonstrated that in each social situation an animal encounters, a particular relationship with the other animal(s) will be established. Attempts were made to control for any effects of this nature as competition was assessed outside the social colony and the purpose of this experiment did not involve forming a linear hierarchy. Moreover, the fact that a transfer of performance did occur between the majority of the dyads does offer support that physical presence of one's opponent is not as important as perhaps other variables, such as one's "skill" to compete, ability to adapt to novel situations in which one must compete for food, or ability to attain concepts regarding the contingencies in various competitive situations.

It is not possible from the present study to identify which if any of these possible variables was operating. Perhaps altering the screen configuration so that a position bias could not develop would provide some further insight. Furthermore, it would be useful in the future to examine the effects of learning on performance within each dyad by repeating the testing series. A situation in which the responses of the animals were not interdependent would permit a systematic analysis of the behavior of the animals
and possibly illucidate the strategies employed during competition.

It is important to highlight the purpose of this research by briefly summarizing the conflicts associated with the area of interest. In the past it has been common among researchers to assume that the outcome of a competitive interaction between animals can be called a dominance hierarchy. It is contended however, that this practice obscures the true hierarchy and ignores that possibility that dominance rank may vary with the social context (Bernstein, 1980). Without knowledge of the social context, it is difficult to assess the nature of a dominance hierarchy and in fact, fruitless to do so. Hierarchies do not exist in a vacuum; social contexts are necessary components for these types of relationships to exist. Further, Fedigan (1982) asserts that dominance is not a permanent trait which animals possess. It reflects the nature of the relationships between animals and therefore, is subject to change as the animal's social environment changes. As illustrated by several authors (Bernstein, 1980, 1981; Brennan & Anderson, 1988; Fedigan, 1982), in a group context, the effects of social status and competition are virtually inseparable.

However, this study demonstrated that it is possible to assess competitive behavior using a video-task paradigm. Although the social relationship of the animals is linked to
their competitive performances, competition in regard to foraging can be studied within alternative paradigms. Each animal possesses some level of competitiveness. It is the expression of competition that was examined in the present study.

The goal of this study was to assess the importance of the physical presence of the opponent. Because severe physical oppression rarely occurs in primate societies, the absolute physical presence of the opponent may be a secondary factor that is operative in maintaining the level of competitive efficiency one may possess. The literature to this date has not attempted to present a computer simulated competitive foraging situation in rhesus monkeys. The research has focused on field studies or group interactions in the lab to understand the influence of social interactions in competitive encounters. These studies have illustrated that it is extremely difficult to control the sociality that one is also attempting to use as an independent variable. The present study had the advantage of utilizing the computer interface to explore the aspects of foraging under a more stringent methodology.

This study has demonstrated that the computer task paradigm may serve as a method of systematically studying variables influencing the foraging situations that have been studied less successfully in the field. Gaining an understanding of how competition would interact with such
factors as patch density, foraging party size, value of food reward, etc., would advance the field of optimal foraging significantly and provide insight into the nature of competition among various species of primates.
Appendix A

An Example of the Behavioral Checklist Used in Phase I
### Appendix A

**Observation Table**

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<th>Trial</th>
<th>Animal</th>
<th>Response</th>
<th>Enr. Recip.</th>
<th>Scratch</th>
<th>Weapon</th>
<th>Display</th>
<th>Grab</th>
<th>Slap</th>
<th>Bite</th>
<th>Clutch</th>
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**Bud = B**
**VERN = V**
**Einstein = E**
**Skeeter = S**

**Notes:**
Appendix B

Combinations of Dyads Tested in Phases I and III

1. Einstein and Vern
2. Skeeter and Bud
3. Skeeter and Einstein
4. Bud and Vern
5. Vern and Skeeter
6. Einstein and Bud
Appendix C

Percentage of Wins for Each Animal by Position Within Each Dyad
Phase III -- Einstein & Vern

Sessions:

Graph showing sessions with bars for right and left categories.
Phase III -- Skeeter & Bud

Sessions
Phase III -- Skeeter & Einstein
Phase III -- Bud & Vern

Sessions
Phase III -- Vern & Skeeter

Sessions
Phase III -- Einstein & Bud
References


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Effects of competition on video-task performance in monkeys. Journal of Comparative Psychology, 104, (2), 115-121.