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ABSTRACT

The literature on the psychological construct of state is reviewed, and it is proposed that state be defined in terms of an infant-environment interaction. Interactive behavior of 32 mother-infant dyads was observed in the home for a total of 2 hours for each pair, in order to explore various types of interactive processes and analyses. A checklist divided into 10-second intervals included various observed behaviors, for example; infant fret/cry, vocalize, play, smile, and eat; and mother touch, hold, vocalize, play, change, and feed. The data seemed to support the proposed model of state, namely that infant condition (behavior) alone was insufficient to describe state since often the same condition had widely different consequences which in turn should affect future conditions. The data also revealed individual differences as a function of the sex of the infant. Briefly, girls received more distal responses to the same behavior for which boys received proximal responses. This finding was discussed as an important source of individual variance and its effect on subsequent cognitive functioning. (Author/NH)

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STATE AS AN INFANT-ENVIRONMENT INTERACTION: AN ANALYSIS OF MOTHER-INFANT BEHAVIOR AS A FUNCTION OF SEX

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State as an Infant-Environment Interaction: An Analysis of Mother-Infant Behavior as a Function of Sex[1]

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State is one of those psychological constructs which is widely used, carries meaning for commerce and yet, when carefully considered, is rather difficult to define. It is clearly an important characteristic of human behavior and is probably one of the more important variables distinguishing the living from the inanimate, such as machines. Yet, its definition is most difficult and soon gives way to simple taxonomy.

State is usually considered, first of all, as a continuum of behavior, reflecting some underlying condition. This condition is usually defined along either an arousal continuum or a consciousness continuum. In contemporary psychology the notion of consciousness--as the entire issue of phenomenology--has been neglected, so most investigations deal with state in terms of arousal. Duffy's (1962) definition of arousal demonstrates the breadth of this concept. It is conceived as a generalized drive state providing, for example, the intensity dimension of the emotions, the alertness factor in intelligence and the general level of reactivity to stimulation--a rather inclusive dimension. The consciousness continuum is less well defined, but has within it the notion of awareness--either internal or external (see Hilgard, 1969).

Given that state is usually defined as an arousal continuum, it would be easy to define state explicitly as some continuum in a specific behavioral area of choosing that continuum as a function of the model of behavior we wish to employ. Thus, if one were talking about brain function, one would discuss state (and state changes) in terms of EEG or REM behavior during various levels of sleep.

Construction of autonomic nervous system models would describe state in terms of heart rate level, while activity models would measure movement, smiling and sucking changes. Attention could be considered a state and state in this case could be defined as the continuum of eye gaze duration. The fact, however, that one can discuss state at these different levels should at once alert us to the problem that the definition of state will be no easy task. Moreover, by defining it in terms of the behaviors studied, the risk of circularity of definition is increased: defining state as eye gaze and using eye gaze duration to define state.

Behind much of this difficulty of definition rests the general belief that the state or arousal continuum varies from a quiet sleep level (non-REM) through an alert level to a super-active level such as crying or extreme anxiety. The arousal continuum is a difficult and contradictory concept which necessarily does not have a one-to-one correspondence with state. For example, there may be more activity (level of arousal) during active sleep than during an alert-attentive period when no activity is present. This point has been made by Lacey (1967) in terms of autonomic nervous system activity.

An alternative procedure is to avoid the issue of meaning (at least temporarily) and to turn to a lower level of epistemology, namely taxonomy. The section below classifies the various ways state is handled in the literature. Completing this, the discussion will return to an alternative way of dealing with state and then move to some recent empirical findings.

A Brief Taxonomy

State has been studied in many different ways but five categories seem to encompass most of them. These categories follow along with some examples of each.

1. Changes in specific state. Mapping the changes in a particular state as a function of some variable, such as age, has received some attention in the literature. More specifically, amount of time spent awake (or asleep) and amount of REM or non-REM sleep are two such examples. An example of the former can be found in the work of Parmelee and his associates (Parmelee, Schulz, & Disbrow, 1961; Parmelee, Wenner, & Schulz, 1964) and Dittrichová and Lapáčková (1964). As would be expected, normal term infants spend more time asleep than awake and this ratio changes as the infant becomes older. In the Dittrichová and Lapáčková data, two-week-olds were awake (had their eyes open) approximately 10 per cent of the time while by 24 weeks they were awake 47 per cent of the time. The work of Roffwarg, Muzio, and Dement (1966) is an example of REM state changes with age. They have reported that normal newborns spend at least one-half of their sleep in the REM state and this ratio decreases progressively with age.

The acquisition of these developmental changes is very useful, first for the mapping of the process itself, but also in determining the maturational age of an infant by comparing the individual function with known normative data. Special comparisons have been made with premature infants (Parmelee, Wenner, Akiyama, & Flescher, 1964; Parmelee, Wenner, Akiyama, Schulz, & Stern, 1967).

2. Measurement of state. Under this heading must be included all those studies whose function, either direct or indirect, was to relate state to behavioral manifestations. The work in this area is extensive and can be considered only by remembering that state is usually defined in the particular context or model under consideration. Thus, if one were talking about brain

function, state variations would likely be considered as changes in electroencephalography behavior. Alternatively, state can be considered in terms of general EMG activity, respiratory changes, eye activity or even smiling.

In effect, investigators have attempted to correlate state and state changes only with a variety of behaviors and at the same time to define state by these behaviors. Johnson (1970), however, has argued that specific behavior, in this case "EEG and autonomic activity, cannot be used to define states of consciousness. The state of consciousness of the subject must first be known before the physiological significance and possible behavioral meaning of the EEG and autonomic responses can be inferred" (italics added). Johnson's work suggests that state cannot be inferred from behavior, a point which will be taken up later in the paper. It is sufficient at this point to present some sampling of the work relating various states to behavior manifestations and save any attempt at definition of state for later. The problem in correlating state with specific behavioral manifestations is in the initial definition of state, and the circularity of the problem is easily seen.

Consider the behavioral manifestations of different states. Prechtl and Beintema (1964) have offered a five point scale of state which includes in state 1, regular respiration, eyes closed, no movement; state 2, irregular respiration, eyes closed, slight movements; state 3, eyes open, alert, but inactive; state 4, eyes open, gross movements, no crying; and finally, state 5, eyes open or closed, active and crying. Wolff (1966) has described a seven point continuum: regular and irregular sleep, periodic sleep, drowsiness, alert inactivity, waking activity and crying while Brown (1964) has suggested an eight point continuum. More recently Emde and Koenig (1969a) have defined five behavioral categories (sleep, drowsy, sucking, fussing and crying) which are subdivided into states with or without REMs, making a total of ten states. The problem with this type of categorization is that any different number of states can be described. This varies only with the ingenuity of the investigator and the sophistication of the measurement procedure. Moreover it restricts the notion of state to discrete points rather than a continuum.

In a second paper, Emde and Koenig (1969b) find correlates of neonatal smiling and frowning to the various states. Still other behavioral correlates of state are sucking, skin potential (Bell, in press) and EKG rate differences (Bartoshuk, 1964; Graham & Jackson, 1970; Lewis, Bartels, & Goldberg, 1967). Bell (1960) reports a factor analysis in which a variety of behaviors generated five principal factors, two of which were state: arousal and depth of sleep.

The response system most correlated with state is EEG and rapid eye movement--REM. Any number of studies have related various states of sleep and wakefulness and REM behavior (Bartoshuk & Tennant, 1964; Engel & Butler, 1963; Parmelee, Schulte, Akiyama, Wenner, Schultz, & Stern, 1968; Roffwarg et al., 1966), and Ellingson (1967) presents an excellent review of EEG research in infants from fetus through the first year.

3. State and responsiveness. This class of studies is interested in (1) the differences in response to particular stimulation as a function of state or (2) the modification of state by particular stimulation. Although these are not distinct categories, they do afford the opportunity to view some of the research effort. It is true that the stimulation during a particular state can also affect that state and that different states can

be affected differentially. Examples of the first class of studies can be found in Prechtl and his associates' work on reflex responses of waking and sleeping infants (Prechtl, Grant, Lenard, & Hrbek, 1967; Prechtl, Vlach, Lenard, & Grant, 1967). These studies found that the lip-tap reflex and tendon reflexes both varied as a function of state. Lewis et al. (1967), Lewis, Dodd, and Harwitz (1969) and Graham and Jackson (1970) have shown that the cardiac response of deceleration to a variety of stimuli is a function of the state of the infant, this with initial level controlled.[2]

Both Birns and Bridger have demonstrated the effectiveness of various interventions on the state of the infant (Birns, Blank, & Bridger, 1965; Birns, Blank, Bridger, & Escalona, 1965; Bridger, 1965; Bridger & Birns, 1963). Auditory and tactile stimulation do alter such states as crying/upset, with different stimuli having differential effectiveness. These investigators have also found that stimulation of an upset and crying (highly aroused) infant elicits state changes in the direction of quiescence, while stimulation during quiescence tends to activate (arouse) the infant. Brackbill (1970) has reported on the effectiveness of stimulation in a variety of sensory modalities on state change in one-month-olds. Her data demonstrate that quiescent infants become more active and active infants more quiescent under stimulation and that this held most for the extremes of quiescence and activity, e.g., quiet sleep and crying while awake. Moreover, increasing the number of sensory modalities stimulated increased this effect.

The sucking response or oral pacification has been used in order to affect a particular infant's state, in most cases to reduce extremely active states (Cohen, 1967; Kessen & Leutzendorff, 1963; Rovee & Levin, 1966). Lipton, Steinschneider, and Richmond (1960) and Giacoman (unpublished manuscript) have observed the effect of swaddling on state and the results indicate that this is effective in reducing active states.

It is to be noted that in most studies where infants are presented with different types of stimuli there are state changes. For example, an auditory or visual stimulus elicits attention in the infant. Attention itself can be considered a state and this again begs the question of definition since changes in behavior and responsiveness are always varying.

4. Individual differences in state. This category is intended to include studies where individual differences in state were assessed. Individual differences in state can be considered as temperament, such differences between infants in amount of sleeping--waking periods, degree of crying, etc. An individual's state differences in responsiveness to types of stimulation are still another aspect of individual difference. On one hand, work on individual differences is vast if you take as individual state differences such variables as attention, orienting, and temperament. However, restriction of state to the more characteristic considerations narrows the range. Brown's (1964) and Wolff's (1966) work are clearly examples of the study of individual differences under conditions of stimulation and rest (no stimulation). Fish and Alpert (1962) studied state in infants of schizophrenic mothers and concluded that deviations in state compared to "normal" infants were apparent from the first day of life. Schachter, Bickman, Schacter, Jameston, Lituchy, and Williams (1966) studied individual differences in behavioral and physiological reactions and found as Lacey before them (Lacey, Bateman, & Van Lehn, 1953), that response levels in

one variable were not necessarily related to another. While Escalona's (1962) paper on individual differences in state presents no data, she clearly outlines the problem of state in the study of individual differences. More recently, Horowitz's (1965) discussion of individual differences in retardation makes use of individual differences in state (arousal) as they interact with the environment.

5. Some antecedents of state. This category is more difficult to define and any attempt must include such divergent considerations as basic genetic-biological factors--for example, Fish and Alpert's (1962) study on infants of schizophrenic mothers--to the variety of intervention phenomena which range from influencing state by stimulation such as Brackbill's (1970) study of modality effectiveness in quieting, to studies of mother-infant interaction and its effect on state, for example, Moss (1967) and Korner and Grobstein (1966). Finally, while not applying to infant research, there is a body of literature on the effects of biochemical agents on state, for example, the recent work on serotonin depletion and the effects on various sleep states (Weitzman, Rapport, McGregor, & Jacoby, 1968).

It must be again noted that antecedents of state and individual differences become quite broad when the definition of state is reconsidered to include such variables as attention. We might include, then, all the studies on intervention such as Casler (1961) and White and Castle (1964) and those found in the review of Yarrow (1961).

Reviewing the research classified as "state" and categorizing it sheds little additional information in terms of defining state. Instead, for me at least, it tends to demonstrate that our understanding of the meaning of state is limited.

It seems reasonable to conclude from the literature on the premature infant and neonate that differences in state and individual differences in state (for example, amount of time asleep or responsivity to soothing) derive from our biological past and are firmly rooted in our biological composition. It is equally clear from the stimulation and intervention research that state can be modified by the environment.

With this in mind, an attempt will be made to consider state in a somewhat different fashion. Any attempt at reevaluating the concept must be broad enough to encompass the various uses and meanings implied by state and, by the same token, allow for the possible empirical use of such a definition.

State as an Interaction

It is clear from the literature that any exact definition of state is not easily forthcoming. Because of the unwillingness to deal with introspective description, investigators have been forced to define state in terms of organism behavior, which they believe accurately reflects some underlying condition. That is, there has generally been a confusion between measurement and definition. This can be seen most often in the literature where attempts at definition start with state in quotation marks, soon giving way to a taxonomy, then replaced by measurement of specific behaviors. From that point on state no longer appears in quotation marks. This confusion between definition and measurement of specific behaviors can also be seen in the confusion of state as a number of discrete points or state as a continuum. There is relative agreement that state is a continuum of an organism condition, in some cases considered arousal. Yet, while state is generally so considered, our inability to measure it as a continuum results in the consideration of state as a finite set of discrete points. The consequence of this is a literature in which the number of discrete points becomes an issue (or problem) to be dealt with. This is, in fact, nothing but a technology and measurement problem.

In the present discussion, we too are subject to the difficulty of substituting organism behavior for condition; introspective techniques are not possible with infants. An attempt will be made to deal with state not solely as a set of independent behaviors of the organism but rather as some set of behaviors as they interact with the environment. As will become apparent, state (reflected in a set of behaviors) can best be measured as a function of some past set of behaviors of the infant and his environment. Thus state will take on an interactive quality and, therefore, lose some static quality. Moreover, the present analysis allows us to consider models which utilize sequential notions. This will be discussed later in the measurement sections.

Because only behavior rather than condition is available to us, we will deal only with sets of behavior in attempting to specify infant condition. This is compatible with the views of others who have dealt with this problem. Where this discussion differs from earlier formulations is in its stand that behavior is not independent of an interaction with the environment.

In general, state is considered a subject condition--measured by a set of behaviors--which can affect the relationship of the organism to its environment. Thus, the present set of behaviors (B) of the infant will affect subsequent behavior(s). However, it is also true that the set of behaviors will be affected by the interaction with the environment (E). That is, the present set of behaviors at time $\underline{t}$ is also a function of the interaction between the environment and the set of behaviors at $\underline{t}$ - 1: that is,

State $_{\underline{t}} = f(B_t, E_t)$; however behavior at $\underline{t} = f(B_{\underline{t-1}}, E_{\underline{t-1}})$.

Because infant behavior at time $\underline{t}$ is always a function of behavior and environment at $\underline{t}$ - 1, there is a regression with the limit at the time of conception. [Conception is considered the limit rather than birth since it is obvious that gestation itself is an interaction between fetus and environment. Sontag's work clearly demonstrates this interactive effect of maternal environment on the fetus and even on the subsequent state of the newborn (Sontag, 1966; Sontag & Wallace, 1935a, 1935b, 1936). This interactive analysis of regression suggests a limit, namely genotypic structure. It must be remembered, however, that even basic genetic material is placed in an environment which is quite capable of affecting and altering that structure. Young, Groy and Phoenix's (1964) work with altering the sex of monkeys is an example of how environment--in this case hormonal--can affect genetic structure.]

Our argument is essentially that state can be better defined in terms of the type of infant environment interaction with different states being different interactions. For example, "awake state" can be defined as maximum infant-environment interaction, while "sleep state" can be defined as minimum interaction. Likewise, various awake states can be defined in terms of specific interaction. Thus "alert awake" is eyes open-interesting-to-look-at-environment interaction and might be measured, for example, by the duration of eye gaze. However, we propose that there are many more awake states, each of these specific to the interaction. There is an "awake-look state," an "awake-listen state," etc., each a function of the infant and his environment. This is more than possible. To preview some of our empirical results it is possible for two infants to show the same set of behaviors (i.e., eyes open, awake and vocalizing) and have two different environmental interactions. In one case the mother vocalizes back and in the other she touches the child. The results of this interaction are distinguishable and suggest what we wish to call two different states, this when the infant set of behaviors (condition) are identical.

The interactive analysis which has been presented views current state (or a set of behaviors), at time t, a function of past behavior and environment. Equally applicable would be the extension of this analysis to include prediction about subsequent state at t + 1 as a function of t. We suggest that subsequent state and individual differences in state (in sets of behavior) can be predicted best from the infant's behavior and environmental interaction at the present time rather than the infant's behavior alone. This then brings us the power that this type of conceptualization provides. It is believed that this type of interactive analysis will enable one to make a more powerful prediction than the use of either environment or organism variables alone. This appears to be the case. In the appended paper a Markovian analysis of the vocalization data was undertaken and the results, at least for the two subjects considered, indicate that the ability to predict an infant behavior (vocalization) on trial n was enhanced by the knowledge of interaction of the mother's and infant's vocalization on trial n - 1. In both cases, the interaction was superior to knowing mother's vocalization alone on trial n - 1 and in one case knowing infant's vocalization alone on trial n - 1.

People, because they are responsive (more so, at any rate, than the environment in general) may constitute a very important and crucial type of environment, one which is absolutely essential for the growth of the organism (see Lewis & Goldberg, 1969 for a discussion of responsivity). Their effect is of primary importance in determining state. The infant-mother relationship is a special case of the type of infant-environment interaction we have been discussing and it will be this special case which we shall study.

In the subsequent discussion, we shall be dealing with waking states in which there is the opportunity for infant-mother interactions, and we shall look at different waking states. Given the proposed definition, the nature of the interaction will define the state. Thus, for example, an interaction of infant-vocalizing-mother-holding will define a different state from one of infant-vocalizing-mother-vocalizing. It is our hypothesis that different waking periods are different states, this as a function of the mother-infant interaction and that these differential states may determine later states.

Some empirical findings about individual mother-infant interactions as a basis for discussing differential "states" would be relevant at this point. While much import is attributed to the interaction between mother and infant, studies have either discussed it theoretically (for example, Gewirtz, 1969) or have presented data on mother and infant behavior which is not necessarily interactive (for example, Moss, 1967).

Observational Data

Each infant seen was three months old (± one week). The sample of infants seen was deliberately chosen in order to obtain as heterogeneous a group as possible. For this reason boys and girls of two racial groups (black and white) as well as from the entire socioeconomic spectrum (using the Hollingshead five point scale, 1957) were included. There were infants of black professionals as well as infants of poor working class white families. A total of 32 infants have been seen to date.[3]

Each infant-caretaker was seen in her home. Because the caretakers were infants' mothers, the term mother shall be used with the understanding that caretakers could include any other adult.[4] Contact with the mothers was made in a variety of ways: contact through the mothers' initiative, selection of the mother-infant by looking through birth announcements in the newspapers, and through church groups in lower socioeconomic areas. Two observers were trained and used in this study, one for the black community and one for the white. The observer reliability was moderately high, at least for overall frequency of infant behaviors (rho's ranged from .40's to .60's).

The mothers were instructed that the observer was interested in studying the infant's behavior. The observer sat next to but out of sight of the infant. It was stressed that it was the infant who was to be observed--not the mother. Moreover, the mother was to try to forget the presence of the observer and not engage her in conversation. When conversation was attempted, the observer reminded the mother that she was to ignore her. Prior to observation, the observer spent time with the mother attempting to put her at ease.

While every attempt was made to make the observation session as natural as possible, the presence of the observer was bound to have an effect. This problem has been discussed before (see Lewis & Goldberg, 1969); because of the ethical consideration of observation without the mother's knowledge and approval, this was the only procedure available.[5]

Levels of Analysis of Interactive Data

Insert Figure 1 about here

The observation data were collected using a checklist sheet. Each sheet represents 60 seconds, divided into six 10-second columns. Infant behaviors are listed in the upper portion of the sheet, while adult behaviors are in the lower portion. When a behavior not listed on the sheet occurred, the observer wrote it in. For the most part, the behavior categories are self-explanatory. The "extra movement" category consisted of all gross physical movements such as limb movement or rolling of the body. "Quiet play" consisted of the child watching a toy move, playing with his fingers, and noise/

nonvocalization was similar to extra movement, except that noise accompanied the behavior (by kicking feet against the crib). It is clear that these behaviors are not totally exclusive, reflecting a further difficulty in studies of this sort. Although the behaviors have some overlap, the observers were in general able to differentiate between them. Mother's touch and holding categories were used to distinguish between a discrete touch versus a physical support. If during a "hold" the mother also discretely touched the child, both categories would be scored. Finally, the categories of reading/TV and vocalizing to others were used to indicate that the mother was involved in activities not directed toward the child.

Each 10 seconds the observer checked off the occurrence of both infant and mother behaviors, also recording when possible which behaviors preceded which. Figure 1 presents an example from one minute of observation. The numbers "1" and "2" indicate that not only did that particular behavior occur but "1" indicates it occurred before "2" during the 10-second period. The observer only scored initiating and responding behavior (numbers instead of check marks) when she was sure of the direction of the interaction.

Consistent with our interest in different awake states, no sleep data were collected. This meant that if the infant closed his eyes for longer than 30 consecutive seconds, observation stopped. In order to obtain two full hours of eyes-open data, a minimum of two hours of observation and on some occasions as much as three or four hours were necessary. In fact, for one-third of the sample, two visits to the home were required.

Methods of Data Analysis

Various levels of interactive analysis are possible with these types of data. In the following discussion, some of the more obvious will be presented.

Frequency distribution. The lowest level of interactive analysis is the frequency data; that is, how much vocalization, quiet play, smiling, etc., the infant exhibited in the two hours of observation. Likewise, the same data analysis is possible for the mother's behavior. These types of data are the types most reported in mother-infant studies, for they are the easiest to obtain and score.

Simultaneous behavior within 10-second unit. I. The next level of data analysis, the first true interaction, is the number of 10-second units for which there are both a child and mother behavior, this regardless of the nature of the interaction and who initiated the interaction. It is often difficult to determine exactly which one of the pair initiates a behavior sequence and time duration of the sequence. For these reasons a more conservative approach is to restrict the analysis to a 10-second time unit, recognizing that it is an arbitrary unit of time. The observation of the number of 10-second periods in which there was an interaction is a simple interaction parameter which can provide some index of individual amounts of mother-infant levels of interaction. Moreover, by looking at the ratio of number of 10 seconds of infant behavior to number of 10 seconds of interaction, a general environment responsivity score can be obtained.

Simultaneous behavior within 10-second unit. II. A still higher level of interaction involves judging not only that a mother and infant interaction occurred in the same 10 seconds, but the nature of that interaction. For example, consider the summary data sheet for an individual subject in Figure 2. Along the left side are listed the various infant behaviors, while along the top,

Insert Figure 2 about here

the maternal ones. For each occurrence of an infant behavior, it was determined whether there was an interaction. If one did occur, then for each infant behavior the various maternal behaviors were scored. For example, in a 10-second period, an infant vocalized and his mother also vocalized. In the infant vocalization row and maternal vocalization column an occurrence would be scored. Because the mother might have exhibited several behaviors at once, it is possible that several maternal rows would be scored for each infant behavior. It is possible, therefore, that the total maternal behaviors across a row of a specific infant behavior may be greater than the specific number of infant occurrences. However, there can never be more mother than infant occurrences in a single category.

Likewise, one can look at the specific adult behavior and observe what infant behaviors also occurred during the same 10 seconds. It is important to remember that this analysis does not imply direction to the categories of behavior, only that they happened in proximity--in this case within the same 10-second period. While no direction should be inferred, and for such behaviors as infant vocalization and smile it is difficult to surmise who initiates what; such behaviors as infant fret/cry would logically suggest that this behavior elicited maternal behaviors such as look, smile or touch rather than the other way around.

Directional interactive analyses. This level of analysis is designed to try to determine the direction of interactive behavior. Under this analysis, four categories of interactive behavior are possible for each specific behavior. For example, examine an infant vocalization. The first question to be asked is whether the vocalization was a response to a maternal behavior or was an initiator of a maternal behavior, these being scored as two separate categories. This was accomplished by making use of the scoring of a "1" or a "2," "1" indicating initiating. Two additional categories were necessary for interactions with less clarity of direction. For example, the child vocalizes and it was observed that the mother had been vocalizing to the infant for 30 seconds prior to and 10 seconds after the child's vocalization. Does the mother's vocalization constitute an initiation and her vocalization subsequent to the child's, a response? It is not at all clear since the infant did not vocalize immediately. In this case this type of interaction was scored separately. Finally, a fourth category was necessary for interactive behavior whose direction could not be assessed. Thus, for each infant behavior, each maternal behavior had four possible direction components.

There are of course many more measures of interaction for which individual measures may be obtained. For example, one can look at length of interaction, for another, density of response. The latter is a particularly interesting measure of interaction in that it implies that for some behavior there are more maternal responses occurring than for others This density measure is based on the ratio of amount of specific infant behavior, e.g., vocalization, compared to amount of all maternal behaviors during that specific behavior. For example, the data indicate that when an infant smiles there is more maternal behavior than when it vocalizes. We shall return to this measure later.

It is clear that interaction analyses are not easy and this, of course, explains their lack of use in most of the mother-infant analyses. In order to talk about state, it will be necessary, however, to deal with interaction analyses, since we have committed ourselves to a definition of state which rests on just such interactions.

Results

In order to demonstrate individual differences in state--infant-mother interaction--both individual and group data will be presented. Moreover, because much data already exists on individual differences in infant-mother interaction as a function of the sex of the child (Goldberg & Lewis, 1969; Moss, 1967) the group data have been grouped in this fashion.

Frequency distribution. The overall frequency data indicate great individual variability. For example, numbers of vocalizations range from 34 to 309 ten-second units for girls and from 28 to 438 ten-second units for boys. These same types of large individual differences can be found for each infant behavior. It is interesting to note that of all the prominent behaviors, vocalizations were the most numerous--24 per cent of the time.

Insert Table 1 about here

In similar fashion, maternal vocalization frequencies varied from 154 to 493 ten-second units for girls and 101 to 344 ten-second units for boys. As expected, mothers held and vocalized to their infants relatively frequently during the two hours of observation (40 and 36 per cent respectively). Of interest, however, was the fact that mothers smiled to their children less than they read or looked at television (5 to 6 per cent). Group differences as a function of sex of infant reveal no differences in any of the behavior categories. Not so the behaviors of the mothers. These seemed to be determined by the sex of their infants. In general mothers of boys held, touched and rocked their children more than mothers of girls (significant only for hold, $t = 2.09$, $p < .05$, two tailed[6]). Mothers of girls, however, tended to vocalize and look at their children more than mothers of boys (significant only for vocalization, $t = 2.04$, $p < .05$). While this level of analysis tells relatively little about infant-mother interaction, it does suggest that boys receive more proximal stimulation--touching and holding--while girls receive more distal stimulation--looking and vocalization, this when there is no difference in boy-girl infant behavior.

Insert Table 2 about here

In order to examine the relationship between maternal and infant behavior, a correlation matrix was computed. The results indicate that at least for frequency of occurrence there is a relatively strong relationship between infant and maternal behavior. For example, mothers who vocalized and smiled a great deal had infants who vocalized and smiled a great deal (rho = .43, $p < .05$ and .52, $p < .01$, respectively). In general the more the positive maternal behavior, the less infant fret/cry--this significant for hold (-.36, $p < .05$) and smile (-.43, $p < .05$). Like smiling, maternal play behavior was positively correlated with infant vocalization (.49, $p < .01$) and smile (.45, $p < .01$). Maternal looking was positively associated with infant movement and noise/nonvocalization (.44 and .37, $p < .05$, respectively).

Simultaneous behavior within ten-second units. I. The first truly interactive analysis asks in how many ten-second units there were both infant and maternal behaviors. Again, this varied with the infant-mother group, for example, from 208 to 543 ten-second units for girls to 200 to 492 ten-second units for boys. For the group as a whole, there were 341.2 ten-second units--44 per cent of the two hours of observation spent in interaction; boys 359.3 and girls 320.7, a nonsignificant difference.

Also of interest was the percentage of time there was an interaction unit as a function of the number of times there was an infant behavior. These varied for individual infants from a low of 39.5 per cent to a high of 96.5 per cent. For boys it averaged 75.6 per cent of the time with a range of 48.9 to 96.5 per cent while for girls it averaged 68.0 per cent with a range of 39.5 to 91.9 per cent of the time. This difference was not significant, however (t = 1.32).

Simultaneous behavior within ten-second units. II. This interaction analysis begins to examine what happens when something else is happening and is vital to the discussion of state as an infant-mother interaction. It is here where it can be demonstrated that such state differences as infant-vocalization-mother-vocalization or infant-vocalization-mother-hold are possible.

Insert Table 3 about here

Presented in Table 3 is the interaction relationship between infant and mother. Keep in mind that there is no causality implied in this analysis, only that when a child was doing something, his mother also was doing something.

First view the data from the infant point of view. As expected the most common interaction to infant's vocalization is maternal vocalization, then maternal-hold, and finally maternal-look. For infant-gross movement the most common maternal associations are hold, vocalization, and look. Interestingly and somewhat unexpected are the interactions for infant-fret/cry. Infant fret/cry is most associated with maternal-vocalization, hold and look. One might have expected more infant-fret-maternal-hold. Obviously, infant-eat should be and is associated most with maternal feed and hold. Infant-play is associated most with maternal-look, followed by maternal-vocalization, third and surprisingly, maternal-reading or watching TV. Infant-noise is most associated with maternal reading or watching TV and maternal-look followed by maternal-vocalization. Finally, infant-smile is most associated with maternal-vocalization, holding and smiling.

Now consider the maternal behaviors and observe the infant behavior associated with them. This is done by reading down the maternal columns. Maternal-touching is most associated with infant-vocalization and movement while holding is most associated with infant eating, vocalization and movement. Maternal-vocalization and looking are associated most with infant-vocalization, eating and fret/cry, while smiling is most associated with infant vocalization, smiling and infant play. Maternal-play is most associated with infant-vocalization, play and smile and maternal change-diaper is associated with infant vocalization, fret/cry and smile. Of the two behaviors not directed toward the child--vocalization to others and reading and watching TV--infant behaviors most associated were vocalization, eating and playing. It is clear that infant-vocalization is most associated with maternal behaviors.

Insert Table 4 about here

Table 4 presents these same data broken down by sex. It is apparent that the same infant behavior is associated with different maternal behaviors as a function of the sex of the child; that is, different conditions of the subject have different environmental associates and therefore different states. In order to see this more clearly an individual infant-mother interaction analysis

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Insert Table 5 about here

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was performed. This analysis was performed for each infant behavior. The question asked was for each individual infant for a particular behavior what maternal behavior occurred most frequently? The scores in Table 5 reflect numbers of infant-mother dyads. Because there were ties the total number of dyads sometimes exceeds the number of cases. Observation of the data reveals interesting individual differences, especially as related to sex. The data for vocalization, movement, fret/cry, play and noise/nonvocalization all indicate that the behavior associations of mothers of boys tend to be equally distributed between proximal (touch or hold) and distal (look and vocalization) while the behavior association of mothers of girls tends to be loaded in the distal modality. Thus, for example, when a girl infant is vocalizing, her mother is most likely vocalizing as well. However, when a boy infant is vocalizing, it is equally likely that his mother is holding him or vocalizing. This trend in most infant behaviors is significant for infant gross movement ($\chi^2 = 5.43$, $p < .05$).

The same analysis can be performed looking at maternal behavior categories and observing the infant's behavioral associations; that is, when the mother was behaving in a certain fashion what was the infant doing? Thus for maternal touching, one could observe the number of infants showing maximum association for one of the seven categories of vocalization, movement, fret/cry, eating, playing, noise, and smiling. When this analysis is performed, no sex differences are observed. Moreover, much of the maternal behavior is associated with infant vocalization which was reflected in the mean data analyses presented above.

These two analyses suggest then that the sex differences observed are not a function of the infant's behavior but rather differential maternal responsivity as a function of the sex of the infant. State differences between individual infants, often as a function of sex, are apparent even when the infant's condition is constant. For example, large bodily movements or vocalizations (an infant condition) are associated with either distal or proximal maternal behavior (an environmental condition) resulting in differential state, this when the infant condition is consistent. Of particular interest is that girl infants' vocalizations are more likely to be associated with maternal-vocalization than are boys'. The potential consequence of this state difference for subsequent language and cognitive development is considerable.

Directional interactive analyses. Within this analysis the direction, when available, of an interaction is mapped. Table 6 presents these mean data for the group as a whole.[7] Observe the four categories of maternal-

Insert Table 6 about here

infant behavior: A, maternal initiate-infant respond; B, infant initiate-maternal respond; C, maternal-continuing-infant respond; D, undefined. Our attention should be directed to the A and B categories which supply the most accurate of the direction measure. Percentage scores as well as the mean data for A and B categories are presented. These represent the percentage of A to (A + B) and of B to (A + B), and inform one of the percentage of maternal behavior which was a response to (B) or an elicitor of (A) an infant behavior. The final per cent on the right of the table is the percentage of ΣA to $\Sigma(A+B)$ and ΣB to $\Sigma(A+B)$ over all maternal behaviors.

Consider infant vocalization: the data for all maternal behaviors except vocalization indicate that infant vocalizations were for the most part responses to maternal initiated behaviors. Thus, an infant vocalized 83 per cent as a response to a maternal touch "A" and a maternal touch was a response to the infant's vocalization, 17 per cent of the time "B." This held for each maternal behavior with varying degrees of differential magnitude. Maternal vocalization, however, was more likely a response to the infant's vocalization

"B" than an initiator of the behavior "A." Interestingly, this also held for maternal vocalization to others.

Infant smiling behavior like infant vocalization is for the most part more of a response to maternal behavior "A" than an elicitor of her behavior "B." Indeed this holds for every maternal behavior. Infant fret/cry, gross movement and play, however, are elicitors of maternal behavior, this for most every category of behavior.

There would seem to be two classes of behavior for infants of this age, those which elicit maternal behavior such as fret/cry, gross movement and play and those which are the result of maternal behavior, smile and vocalization (see total behavior percentages in Table 6). Vocalization is a particularly interesting behavior partly because it has both qualities: it is the response more than the elicitor to all maternal behaviors except for maternal vocalization where it is more often the elicitor. The results point up the difficulty of a simplistic approach which often fails to take into account the real interactive quality of the mother-infant relationship. Moreover, and perhaps more importantly, the results suggest that different behavior sequences have different histories of initiator-respondent relationship. Thus, it is clear that infant smiling is for the most part a response to something while fret/cry is for the most part an elicitor of some response on the part of the mother.

Observation of maternal behavior across all categories of behavior indicates a differential initiator-respondent pattern dependent on the behavior. For example, for maternal touch, hold, look, smile, play, and change diaper, the mother's behavior is as an initiator of infant behavior (averaged across all behaviors) while mother's vocalization, feed, rock, vocalize to others and read/TV are responses to infant behavior.

Insert Table 7 about here

A breakdown of the data by sex is presented in Table 7. As was the case for the group as a whole, infant vocalization and smile were more often a response to a maternal behavior (with the exception of infant-vocalization-maternal-vocalization). There do appear, however, to be some interesting sex differences in the degree to which this was true. Comparing only the A and B categories over all the maternal behaviors, 50 per cent of directional vocalizations for males were responses to maternal behavior, "A," while 50 per cent were elicitors, "B." For females the percentages were 63 in response to maternal behavior and 37 initiators of maternal behavior. This suggests that females may be more vocally responsive--in proportion to vocalization in general--to a mother's behavior than males. The fret/cry data are also suggestive of sex differences. In this case, mothers of girls are more likely to respond to a fret/cry than are mothers of boys.

Of particular interest is the observation of amount of responsivity on the part of the mother to an infant's behavior as a function of each specific infant behavior. This can be determined by the comparison of the mean difference data. It is recognized that sex differences in frequency need to be taken into account; however, the frequency data presented earlier failed to indicate any sex differences. Thus for a preliminary descriptive analysis the mean data will suffice. For infant vocalization, mothers of boys are more responsive than mothers of girls, this for every category of maternal behavior except for vocalization where mothers of girls are more responsive. This suggests two important considerations. First and more general, addition across several classes of events may result in failure to find differences (in this case sex). Second, and more specifically, while mothers are as responsive to vocalization in boys as in girls--perhaps even more so--it cannot be generalized to every behavior. In fact, mothers vocalize more to girls' than to boys' vocalizing.

For infant movement, mothers of boys tend to be more responsive than mothers of girls except for maternal smiling where the reverse is true. Infant play shows similar results, more maternal response for boys than girls. An infant's fret/cry produces the opposite trend; in general mothers of girls are more responsive to a girl's fret/cry than mothers of boys to a boy's fret/cry; the only category where this fails to hold is maternal look. Likewise, girls' smile produced more maternal response than boys'. Again a complex interaction of maternal response-infant behavior and sex of the infant is apparent. For both affect behaviors--fret/cry and smile--mothers of girls are more responsive than mothers of boys. For the other infant behaviors the reverse is true.

The analyses so far are just a part of the complexity one encounters when a truly interactive study is undertaken. Before trying to summarize the results and their relationship to the issue of state, two further analyses will be presented.

Insert Table 8 about here

Density measures. Observation of maternal-infant interaction often reveals that for any particular infant (or maternal) behavior the number of different maternal (or infant) behavior associations vary. Specifically, a density measure is designed to ask what types of infant behaviors are most likely to be associated with more different maternal responses. It is in fact a ratio score of total simultaneous interaction scores over the number of infant behaviors. Thus a score of one or less means that maternal responses associated with the particular infant behavior occur less often than the occurrence of the specific infant behavior. Scores greater than one indicate increased density. Remember that one or more maternal behaviors are possible for each infant behavior.

The group data are unequivocal, infant smiling has the most dense associated maternal behavior, with little mean difference between boys and girls. Like most interactive measures, however, there is great individual variability, 1.27 to 5.00 different behaviors for boys and 0.83 to 4.70 for girls. Infant vocalization, movement, and fret/cry have the next most dense response and finally infant play and noise the least. In each case individual density scores vary widely. In fact an average density score over all the infant behaviors ranges from 0.88 to 3.40 for boys and 0.86 to 4.60 for girls. The analysis and its interpretation is made somewhat confusing because some of these infant behaviors are characteristically elicitors of maternal behavior while some are responses to maternal behavior. In the case of fret/cry, movement, play and noise--all elicitors of maternal behavior--the different density scores reflect different amounts of maternal response density whereas for infant vocalization and smile--both responses to maternal behavior--these different density scores reflect different amounts of maternal eliciting density. The difference between vocalization and smile suggest that mothers exhibit more behaviors in order to get their infants to smile than to vocalize. The difference between infant movement and fret/cry and play and noise indicate that movement and fret/cry produce greater density of response than play and noise. This makes some sense when it is considered that movement and fret/cry are associated with discomfort whereas play and noise are not. That is, mothers are more responsive--in terms of density--to their infants' discomfort.

Sequences and other chaining analyses. To attempt to go into an extensive discussion of the various sequence and chaining analyses is too complex for the present report. Suffice it to say that there are a variety of mathematical operations which are capable of dealing with sequential data. For example, it is possible to categorize the vocalization data into no one vocalizes, infant vocalizes alone, mother vocalizes alone to infant, she vocalizes to some other, mother and infant both vocalize, and mother vocalizes to some other and infant vocalizes. It is then possible to assign one of these categories for each of the 720 ten-second units. Using this procedure one could apply a Markovian model to the data and generate such response parameters as category run, e.g., the number of consecutive ten-second units of a particular category. In a general sense this type of analysis enables one to determine the conditional probabilities of the next ten-second unit knowing what is occurring during the present ten-second unit. Individual differences in these parameters can be determined. Markovian models have special appeal to our definition of state since they deal with current state (interaction) in time t as a probability of state in $t - 1$, thus making state the fluid and dependent interaction it is believed to be.[8]

Discussion

Since two interrelated but separate issues have been raised, the nature of the paper predicates a broad discussion. The first issue deals with the more theoretical construct "state," while the second is concerned mostly with methodological problems, namely, the measurement of interactive processes. Concurrently data are presented in an attempt to examine empirically the interactive behavior of 12-week-old infants and their caretakers. It is probably more profitable to deal with each of the two issues separately.

Definition of many psychological variables, even when attempted, is often unsatisfactory. While taxonomy is valuable, periodic attempts at definition are useful if only to demonstrate that the concept under study is complex and in some cases far from clear in meaning. The concept of state is no exception to this rule. The examination of the current usage and definition of the term leads one to conclude that state is a widely used concept varying in meaning--not to mention measurement. It has been considered a continuum of behavior usually along an arousal dimension and yet examined as discrete categories. It has also been considered a condition of the organism (levels of consciousness being one such condition), yet little systematic investigation of self-report has been undertaken. A notable exception is the recent work on alpha conditioning in which subjects report their own consciousness level (Kamiya, 1969).

In terms of the common definition most of us would agree that state is a condition of the organism. However, the notion of condition is most general. "I'm in a state," implies some affect-emotional dimension; "I'm ready," implies some alerting dimension while, "I'm tired" implies some wake-sleep continuum. Each, however, refers to the organism's state or condition and suggests that state has wide dimensions. The subject's condition also informs us of how the organism is or will be behaving, although the correspondence between the two--condition and behavior--may be weak and inference from one to the other difficult. It is important to note that Johnson (1970) in his presidential address before the Society for Psychophysiological Research entitled "A Psychophysiology for All States" cautioned his audience that condition must <u>first</u> be known before the significance of behavior can be inferred.

While state implies organism condition it must also be considered that the subject's state is not some static and basic genotypic condition. At no point is an organism's condition not interacting with and being altered by environment. In fact a better term than state or condition may be organism status, for status implies just that interactive relationship which has been suggested. For example the search for genotypic temperament differences among infants may be futile, not because there are no individual differences in temperament but because the important individual differences are in the interaction of temperament with environment. One infant is not more hyperactive than another, he is more active under one environmental level--high stimulation--but not another. The analysis is even more complex: that is, not only are the phenotypic behaviors a function of environmental interaction but what we at first consider to be genotypic are themselves affected by environmental interaction. I am referring specifically to neonatal differences in activity levels which Sontag (1966) has related to maternal-environmental interactions.

To define state in terms of behavior-environmental interaction does broaden the concept. In this form any subject behavior-environmental interaction is classified as state. Is this definition then too broad to be of value? We think not, because it forces those of us who construct models of human behavior to remember that most, if not all, human behavior is interactive.

This aspect of our discussion leads directly to the next: the use of interactive analyses. The analyses of interaction between condition and environment have been limited to infant and caretaker (mother) interactions. This is, of course, not a requirement of the model. Indeed the mother as environment is a very special case of environment because of several important characteristics. First, to varying degrees, she is responsive. Second, she is both constant and variable. She can respond consistently to her infant's vocalization with a vocalization and yet these need not be the same vocalizations. These qualities are most important for the emergence of schemata and the development of permanence and constancy over perceptual variance. And third, she is usually the provider of all the infant's biological needs. These and more make the infant's mother a unique aspect of the environment. The first two qualities, however, have special environmental implication. For example, could machines be constructed and programmed to function as well as the mother? Perhaps it would be possible but consideration soon reveals an almost total lack of information on normative or individual differences in mother-infant interactions. Even if enough were known about the occurrence of an infant's behavior repertoire, almost nothing is known about the nature and frequency of the mother's responses to the infant's behavior. Moreover, simple observation of mother-infant interaction reveals that the mother is often the initiator of behavioral sequences rather than solely a respondent to infant initiated behaviors. The dimensions of these various interactions are immense! Some of them have been suggested within this paper.

The difficulty of any interactive approach can be easily seen in the paucity of information on mother-infant interactions. There are almost no studies which deal with the interaction itself. Most often the mother's behavior is counted as is the infant's behavior, and in that they occurred at the same time, interaction is assumed. The power of interaction analyses are for the most part lost under this strategy.

The problems of interactive study present themselves in several areas; first, interaction is difficult to observe; second, the dimensions of interactive behavior are legion--the examples given within this paper are far from exhaustive--and, third, the statistics for handling individual differences are not always available.

The observation problems are many, not the least of which is the effect of observation itself. Putting aside this problem, it is extremely difficult to determine which actor initiates what and whether one behavior is indeed a response to another. For example, behavior which is assumed to be initiative can in fact be nothing more than background noise unrelated to an occurrence of the other actor's behavior. A mother singing to her child can be background while a brief and slight position change can be the "real" initiator of the infant's vocalization. Still another problem is the inference from behavior, namely the assumption that since a mother's vocalization precedes that of her infant, the mother's behavior is an elicitor of the infant's or that the infant's behavior is a reinforcer of the mother's or both. The notions of intentionality and causality can be avoided, but to do so often involves searching for elaborate and confusing phraseology. Our constructs are insufficient at this point to carry the meaning we often wish to imply.

Another class of issues is the various and seemingly unlimited different analyses of interaction and the statistical handling of them since they are often not independent but nested concepts. The development and use of mathematical models such as a Markovian procedure, which will be demonstrated in the following appended paper, is an exciting possibility for handling some of these data. In the body of this paper some of these different analyses are presented and in a recent study by Lusk and Lewis (1971) some further types have been explored. Unfortunately, the exploration of many of these analyses is still in the descriptive stage and must await further refinement and statistical elaboration. We consider the present paper as a first attempt at coming to grips with this problem.

The results of the empirical work bear on the theoretical issue of state as well as provide information on individual differences in state, in part as a consequence of the sex of the infant. It is apparent that there are large and interesting differences among the mother-infant dyads in interactive behavior. In the simplest analysis, the amount of interaction varied between 28 to 75 per cent of the total observation time, a difference of approximately three times across different dyads. These individual differences can be seen on every level of analysis. Of particular import is the simultaneous analysis of behavior wherein it was demonstrated that there were large differences in environmental response to the same infant behavior. For example, mothers' behaviors tended to be quite different toward infant movement. For some infants--usually girls--infant movement was associated with responses of vocalization or looking whereas the same behavior in others--more often boys--was associated with touching and holding. In general, the same infant condition across the sexes was associated with more distal behavior for girls and more proximal behavior for boys. Thus for one child infant-vocalization-maternal-vocalization was common whereas for another infant-vocalization-maternal-hold was likely. Recall the model of state; it was defined as the behavior-environment interaction. In this case of vocalization, different awake states are evident: vocalize-vocalize versus vocalize-hold, this when infant behavior (vocalize) was constant. That these different waking states are sex-related may account for sex differences in other areas of behavior--such as language acquisition, for example--is beyond the scope of this paper. It is important to notice that individual differences in the waking state are possible under the present working definition, even though the two infants are doing the same thing. Moreover, the means and degree to which the difference in environmental responsivity-infant condition affects subsequent infant condition (the likelihood to vocalize again) remains open to speculation. Within the present theoretical framework, certain states increase that likelihood. The answers await empirical verification.

In general one large source of individual variance in interaction could be accounted for by the sex of the infant. While there were little differences between the sexes in frequency of behavior, consistent differences were found in the maternal response toward the child as a function of its sex. To begin with, the frequency of maternal behavior toward the child showed sex differences similar to those described earlier. Mothers of boys showed significantly more proximal behavior than mothers of girls, whereas mothers of girls showed more distal behavior than mothers of boys. These results are in agreement with those reported by Moss (1967) for infants of the same age. Not only do the frequency measures show these differences but they appear in most of the interactive data as well. The various measures indicate several sex-related phenomena. For example, the interaction between mother and infant as a function of the sex of the infant does not exist uniformly across all infant behavior. In fact, the data suggest that for affect behaviors--fret/cry and smile--mothers of girls are more responsive than mothers of boys, whereas for the other infant behaviors the reverse is true. Even within an infant behavior the analysis is complicated. For infant vocalizations mothers of boys are more responsive than mothers of girls for all maternal behaviors <u>except</u> that of vocalization where mothers of girls are more responsive. Thus the interactions between infant and maternal behaviors as a function of the sex of the infant are not simple. This strongly suggests that a revision is needed in some of our notions of more or less maternal response. It is time to consider more fully the quality and type rather than quantity.

In the case of sex differences, the data from Moss and the present study as well as a longitudinal study by Lewis and Ban (1971) on mother-infant attachment all point to this problem. These data indicate that mothers of boys and girls do not necessarily differ in amounts of responsiveness but rather in the nature of that responsiveness: in the early months girls receive more distal stimulation than proximal whereas the reverse is true for boys. When these different behaviors are pooled as in the case of the total interaction unit analysis (see page 16), sex differences are washed out.

As an aside, it is important to note that these two types of maternal response--proximal and distal--have differential developmental courses. The sex differences in distal behavior favoring girls continue through the first two years and remain rather constant in degree. The proximal response which initially favors boys diminishes differentially for the sexes so that by one year of age girls receive more proximal stimulation than boys. By two years, there are no sex differences. It is suspected that the proximal response diminishes faster to boys than girls because of the competing motive of autonomy which is stronger in mothers of boys than mothers of girls. This developmental course points up still another complexity in the study of interaction for it demonstrates the instability of maternal behavior over time--still another complication in the study of mother-infant interaction.

Summary of so long an argument is difficult. Briefly it has been proposed that state be defined in terms of an infant-environment interaction. In order to investigate state differences as well as individual differences in state it was necessary to explore and discuss various types of interactive processes and analyses. Having accomplished this task--a no easy job--empirical data were presented which seemed to support the proposed model of state, namely that infant condition (behavior) alone was insufficient to describe state since often the same condition had widely different consequences which in turn should affect future infant conditions. The data also revealed individual differences as a function of the sex of the infant. These were discussed as an important source of individual variance.

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Footnotes

[1]This research is supported by the National Science Foundation, Grant #GB-8590, and an Early Childhood Research Council Grant. Recognition is to be given to Pamela Sarett and Yvonne Watson for data collection and to Cornelia Wilson for data analysis.

[2]Initial level itself has been used to describe state and also affects response. It is therefore necessary to remove the effect of initial level in order to determine the direct effect of state.

[3]Since our interest here is in process, we shall forego a discussion of individual differences as a function of race or SES, variables which we do not consider to be psychological in nature. A diverse sample was obtained in order to maximize the individual variance in order to maximize mother-infant differences in process.

[4]In a recent study of African infants (Lusk & Lewis, 1971), we found little difference in caretaking between various adults and children. Whether this holds in our culture is yet to be determined.

[5]We cannot assess directly the effect of being observed on the caretaker's behavior. It is possible, however, to manipulate the observer, for example, use males or females, etc. and see what effects observer characteristics have on the caretaker's behavior. In this manner we might be able to surmise the effect of being observed.

[6]All probabilities are two-tailed unless stated.

[7]Seven cases are missing because of the failure of the observers to utilize the present system.

[8] I am most indebted to Roy Freedle for bringing this use of a Markovian model to my attention. A separate paper is included where we demonstrate this procedure in detail.

Table 1

Mean Frequencies of Infant and

Maternal Behavior

	Total (N=32) $\bar{X}$	Boys (n=17) $\bar{X}$	Girls (n=15) $\bar{X}$	t	p
Infant					
Vocalize	170.8	172.1	169.2	.08	NS
Movement	96.5	87.4	106.7	1.35	NS
Fret/Cry	77.3	72.8	82.3	.46	NS
Play	108.0	99.3	117.9	.49	NS
Noise	23.4	17.5	30.1	.92	NS
Smile	37.3	38.6	35.8	.23	NS
Mother					
Touch	126.7	128.7	124.5	.16	NS
Hold	307.3	356.9	251.0	2.09	<.05
Vocalize	257.2	227.1	291.3	2.04	<.05
Look	174.3	145.1	207.4	1.72	NS
Smile	33.0	37.0	28.4	.93	NS
Play	86.8	84.3	89.5	.21	NS
Rock	10.1	14.5	5.0	1.59	NS
Vocalize to others	96.7	109.5	82.3	1.03	NS
Read/TV	48.5	57.1	38.9	.64	NS

Table 2

Mother-Infant Behavior Correlations

(N = 32)

Infant Behavior	Rank Order Correlations								
	Mother Behavior								
	Touch (Kiss)	Hold	Voc.	Voc. to Others	Smile Laugh	Look	Play	Rock	Read/ TV
Vocalize	.11	.11	.43*	-.28	.39*	.21	.49**	.30	.48**
Fret	-.23	-.36*	.02	.15	-.43*	-.36	-.18	-.09	-.36*
Movement	.05	.13	.09	-.15	.08	.44*	.19	.40*	.37*
Play	-.29	-.32	.01	-.28	.23	.04	.31	.25	.35*
Noise (not voc.)	-.15	-.21	-.09	-.13	-.23	.37*	.05	.16	.08
Smile	-.15	-.01	.20	-.26	.52**	-.25	.45**	-.03	.28

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

Table 3

Mother-Infant Interactions (Independent of Direction)

Means for All Subjects (N = 32)

Infant Behavior	Mother Behavior											
	Touch	Hold	Voc.	Look	Smile	Play	Change	Feed	Rock	Toy	Voc. to Others	Read/ TV
Vocalize	28.47	62.13	77.06	47.38	15.78	27.00	10.28	32.41	1.28	1.19	15.88	20.81
Movement	19.06	33.59	30.03	28.75	4.41	8.53	3.66	4.47	1.72	2.09	11.03	12.00
Fret/Cry	13.16	23.34	33.13	14.66	1.81	3.50	4.59	6.50	1.53	2.38	3.59	.91
Eat	6.69	91.75	36.13	37.00	2.47	2.63	0	115.50	3.41	.28	26.19	5.19
Play	8.22	16.31	20.83	22.50	5.38	16.81	2.09	.09	0	.84	10.94	19.22
Noise	1.59	2.50	3.69	5.38	.44	1.97	.66	.19	0	.78	2.06	5.84
Smile	10.69	13.78	25.97	13.44	13.53	14.59	3.59	1.69	.09	.09	1.69	2.03

Table 4

Mother-Infant Interactions (Independent of Direction)

Means for All Subjects by Sex (N = 32)

Infant Behavior		Touch	Hold	Voc.	Look	Smile	Play	Change	Feed	Rock	Toy	Voc. to Others	Read/ TV
		Mother Behavior											
Voc.	Boy	28.82	70.88	71.65	37.53	15.71	25.94	12.94	22.82	1.24	.94	20.00	23.00
	Girl	28.07	52.20	83.20	58.53	15.87	28.20	7.27	23.27	1.33	1.47	11.20	18.33
Mov.	Boy	20.88	38.41	27.12	22.06	3.59	5.88	4.71	5.06	2.65	1.53	10.59	7.41
	Girl	17.00	28.13	33.33	36.33	5.33	11.53	2.47	3.80	.67	2.73	11.53	17.20
Fret/ Cry	Boy	12.35	24.29	32.06	12.65	2.00	3.06	5.41	4.24	2.65	3.18	3.18	1.24
	Girl	14.07	22.27	34.33	16.93	1.60	4.00	3.67	9.07	.27	1.47	4.07	.53
Eat	Boy	7.76	101.53	27.65	32.18	2.53	4.82	0	125.18	4.29	.53	28.82	4.29
	Girl	5.47	80.67	45.73	42.47	2.40	.13	0	104.53	2.40	0	23.20	6.00
Play	Boy	8.41	25.65	21.94	17.59	5.82	19.12	.65	0	0	1.12	10.82	24.00
	Girl	8.00	5.73	19.67	28.07	4.87	14.20	3.73	.20	0	.53	11.07	13.80
Noise	Boy	1.12	2.94	2.29	3.12	.41	2.24	.41	.24	0	.76	1.71	7.35
	Girl	2.13	2.00	5.27	7.93	.47	1.67	.93	.13	0	.80	2.47	4.13
Smile	Boy	10.00	15.00	24.76	11.35	12.76	14.76	4.29	1.82	.18	.06	1.71	3.24
	Girl	11.47	12.40	27.33	15.80	14.40	14.40	2.80	1.53	0	.13	1.67	.67

Table 5

Number of Infant-Mother Dyads Having the Most

Common Interaction (N = 32)

Infant Behavior		Touch	Hold	Voc.	Look	Smile	Play	Change Diaper	Feed	Rock	Pacifier	Voc. to Others	Read/ TV
		Mother Behavior											
Voc.	Boy	0	6	9	0	0	0	0	0	0	0	1	1
	Girl	0	2	10	2	0	0	0	0	0	0	0	1
Mov.	Boy	1	10	4	4	0	0	0	0	0	0	0	0
	Girl	1	2	8	4	0	0	0	0	0	0	1	1
Fret	Boy	1	6	9	1								
	Girl	0	3	11	1								
Eat	Boy	0	7	0	0	0	0	0	14	0			
	Girl	0	4	0	1	0	0	0	13	1			
Play	Boy	0	3	3	2	0	1	0	0	0	0	1	3
	Girl	0	0	3	8	0	0	0	0	0	0	0	3
Noise	Boy	0	3	2	2	0	1	1	0	0	0	0	1
	Girl	0	1	2	6	0	0	0	0	0	0	0	1
Smile	Boy	0	2	15	0	2	1	0	1				
	Girl	0	0	13	4	0	0	0	0				

Table 6

Directed Interactions for the Total Group

(N = 25)

Infant Behavior	Touch A M	Touch A %	Touch B M	Touch B %	Touch C M	Touch D M	Hold A M	Hold A %	Hold B M	Hold B %	Hold C M	Hold D M	Vocalize A M	Vocalize A %	Vocalize B M	Vocalize B %	Vocalize C M	Vocalize D M	Look A M	Look A %	Look B M	Look B %	Look C M	Look D M
Vocalize	5.16	83	1.08	17	19.68	7.72	5.60	88	.80	12	58.40	9.56	23.20	40	34.24	60	26.00	7.20	6.40	73	2.36	27	32.80	8.48
Movement	.16	12	1.12	88	13.96	7.68	.20	83	.04	17	31.60	6.04	2.40	18	10.88	82	12.92	6.44	.40	31	.88	69	17.68	6.72
Fret/Cry	.44	19	1.84	81	6.40	5.28	.24	18	1.12	82	18.12	5.60	2.16	10	18.68	90	9.84	4.96	.20	13	1.36	87	10.80	3.80
Play	0	0	.04	100	6.72	2.96	0	0	.04	100	14.96	3.04	1.40	38	2.32	62	13.40	5.92	.04	17	.20	83	13.40	4.24
Smile	3.88	97	.12	3	6.28	2.20	3.56	98	.08	2	9.76	1.76	11.24	82	2.40	18	10.84	2.76	4.96	98	.12	2	7.44	1.64

Infant Behavior	Smile A M	Smile A %	Smile B M	Smile B %	Smile C M	Smile D M	Play A M	Play A %	Play B M	Play B %	Play C M	Play D M	Change A M	Change A %	Change B M	Change B %	Change C M	Change D M	Feed A M	Feed A %	Feed B M	Feed B %	Feed C M	Feed D M
Vocalize	5.88	68	2.76	32	5.64	4.88	7.88	94	.48	6	18.24	3.96	.72	86	.12	14	7.80	1.92	.80	71	.32	29	23.24	3.28
Movement	.20	16	1.04	84	2.08	2.28	.24	55	.20	45	5.64	2.52	0	0	0	0	3.12	.64	0	0	.20	100	4.36	.84
Fret/Cry	0	0	.20	100	.20	.88	0	0	.76	100	2.28	1.52	.04	33	.08	67	[illegible]	.84	0	0	.28	100	5.76	1.96
Play	.04	10	.36	90	2.84	2.88	.04	50	.04	50	13.80	3.84	0	0	0	0	1.84	.40	0	0	0	0	0	0
Smile	5.80	81	1.36	19	3.36	3.28	5.92	98	.12	2	8.40	1.84	.56	100	0	0	2.40	.64	.20	83	.04	17	1.28	.40

Infant Behavior	Rock A M	Rock A %	Rock B M	Rock B %	Rock C M	Rock D M	Toy A M	Toy A %	Toy B M	Toy B %	Toy C M	Toy D M	Vocalize to Others A M	Vocalize to Others A %	Vocalize to Others B M	Vocalize to Others B %	Vocalize to Others C M	Vocalize to Others D M	Read/TV A M	Read/TV A %	Read/TV B M	Read/TV B %	Read/TV C M	Read/TV D M	Total Mean Per Cent A %	Total Mean Per Cent B %
Vocalize	.04	25	.12	75	.92	.44	.08	100	0	0	.04	.52	.12	11	1.00	89	10.76	7.03	.20	62	.12	38	6.52	1.40	56	44
Movement	0	0	.12	100	1.52	.52	.28	100	.04	0	.48	.52	0	8	0	92	7.36	5.32	0	0	0	0	10.88	2.96	21	79
Fret/Cry	0	0	.04	100	1.24	.36	.04	17	.20	83	.36	.84	0	0	.08	100	1.64	1.64	0	0	0	0	.24	.04	11	89
Play	0	0	0	0	0	0	0	0	.04	100	.32	.16	0	0	0	0	7.52	4.56	0	0	0	0	15.24	3.24	33	67
Smile	0	0	0	0	.12	0	0	0	0	0	0	.04	.04	100	0	0	.80	.72	0	0	.04	100	1.28	.16	89	11

Table 7

Directed Interactions by Sex

(males n = 14, females n = 11)

Infant Behavior		Mother Behavior																							
		Touch						Hold						Vocalize						Look					
		A		B		C	D	A		B		C	D	A		B		C	D	A		B		C	D
		M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M
Vocalize	Boy	4.07	73	1.50	27	19.64	9.29	3.64	74	1.29	26	65.79	11.36	18.43	36	32.07	64	24.86	8.93	4.79	63	2.86	37	25.86	8.00
	Girl	6.55	92	.55	8	19.73	5.73	8.09	98	.18	2	49.00	7.27	29.27	44	37.00	56	27.45	5.00	8.45	83	1.73	17	41.64	9.09
Movement	Boy	.14	9	1.43	91	13.36	8.14	.14	100	0	0	35.93	7.07	2.57	18	11.50	82	9.21	6.29	.50	27	1.36	73	9.86	6.21
	Girl	.18	20	.73	80	14.73	7.09	.27	75	.09	25	26.09	4.73	2.18	18	10.09	82	17.64	6.64	.27	50	.27	50	27.64	7.36
Fret/Cry	Boy	.29	16	1.50	84	4.93	5.00	.14	12	1.00	88	17.64	5.14	1.93	10	16.86	90	9.14	4.29	.14	8	1.71	92	7.86	3.07
	Girl	.64	22	2.27	78	8.27	5.64	.36	22	1.27	78	18.73	6.18	2.45	10	21.00	90	10.73	5.82	.27	23	.91	77	14.55	4.73
Play	Boy	0	0	.07	100	6.07	2.79	0	0	0	0	23.50	4.79	1.71	36	3.00	64	14.14	7.07	0	0	.36	100	14.14	4.79
	Girl	0	0	0	0	7.55	3.18	0	0	.09	100	4.09	.82	1.00	41	1.45	59	12.45	4.45	.09	100	0	0	12.45	3.55
Smile	Boy	3.79	100	0	0	5.71	2.00	2.57	100	0	0	11.21	1.93	9.79	77	2.86	23	10.79	2.57	3.86	98	.07	2	6.57	1.36
	Girl	4.00	94	.27	6	7.00	2.45	4.82	96	.18	4	7.91	1.55	13.09	88	1.82	12	10.91	3.00	6.36	97	.18	3	8.55	2.00

Infant Behavior		Smile						Play						Change						Feed					
		A		B		C	D	A		B		C	D	A		B		C	D	A		B		C	D
		M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M
Vocalize	Boy	4.64	62	2.86	38	5.71	5.43	5.71	91	.57	9	19.71	4.36	.93	82	.21	18	11.00	2.21	.57	50	.57	50	21.86	3.21
	Girl	7.45	74	2.64	26	5.55	4.18	10.64	97	.36	3	16.36	3.45	.45	100	0	0	3.73	1.55	1.09	100	0	0	25.00	3.36
Movement	Boy	.21	20	.86	80	1.21	1.93	.07	25	.21	75	4.07	1.93	0	0	0	0	4.43	.79	0	0	.21	100	5.00	1.07
	Girl	.18	12	1.27	88	3.18	2.73	.45	71	.18	29	7.64	3.27	0	0	0	0	1.45	.45	0	0	.18	100	3.55	.55
Fret/Cry	Boy	0	0	.14	100	.07	.21	0	0	.43	100	1.86	1.71	.07	33	.14	67	2.64	1.00	0	0	.21	100	4.14	1.29
	Girl	0	0	.27	100	.36	1.73	0	0	1.18	100	2.82	1.27	0	0	0	0	3.73	.64	0	0	.36	100	7.82	2.82
Play	Boy	0	0	.21	100	3.07	3.00	0	0	.07	100	16.07	4.64	0	0	0	0	0	0	0	0	0	0	0	0
	Girl	.09	14	.55	86	2.55	2.73	.09	100	0	0	10.91	2.82	0	0	0	0	4.18	.91	0	0	0	0	0	0
Smile	Boy	4.86	82	1.07	18	3.14	3.86	5.00	99	.07	1	8.64	1.93	.64	100	0	0	3.00	.79	.07	100	0	0	1.36	.36
	Girl	7.00	72	2.73	28	3.64	2.55	7.09	98	.18	2	8.09	2.73	.45	100	0	0	1.64	.45	.36	80	.09	20	1.18	.45

Infant Behavior		Rock						Toy						Vocalize to Others						Read/TV						Total Mean Per Cent	
		A		B		C	D	A		B		C	D	A		B		C	D	A		B		C	D	A	B
		M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M	M	%	M	%	M	M	%	%
Vocalize	Boy	.07	25	.21	75	.93	.43	.14	100	0	0	0	.21	0	0	1.29	100	13.64	8.64	.29	67	.14	33	8.21	1.79	50	50
	Girl	0	0	0	0	.91	.45	0	0	0	0	.09	.91	.27	30	.64	70	7.09	5.09	.09	50	.09	50	4.36	.91	63	37
Movement	Boy	0	0	.21	100	2.71	.71	.43	19	.07	81	.29	.29	0	0	0	0	6.93	5.29	0	0	0	0	4.43	1.36	20	80
	Girl	0	0	0	0	0	.27	.09	100	0	0	.73	.82	0	0	0	0	7.91	5.36	0	0	0	0	19.09	5.00	22	78
Fret/Cry	Boy	0	0	.07	100	2.21	.57	.07	19	.29	81	.21	.79	0	0	.14	100	1.00	1.64	0	0	0	0	.21	0	11	89
	Girl	0	0	0	0	0	.09	0	14	.09	86	.55	.91	0	0	0	0	2.45	1.64	0	0	0	0	.27	.09	12	88
Play	Boy	0	0	0	0	0	0	0	11	.07	89	.57	.29	0	0	0	0	7.79	4.57	0	0	0	0	15.50	3.07	31	69
	Girl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.18	4.55	0	0	0	0	14.91	3.45	38	62
Smile	Boy	0	0	0	0	.21	0	0	0	0	0	0	0	.07	100	0	0	1.21	.71	0	0	.07	100	2.29	.29	88	12
	Girl	0	0	0	0	0	0	0	0	0	0	0	.09	0	0	0	0	.27	.73	0	0	0	0	0	0	89	11

Table 8

Density Indexes

	Total Group (N=32)	Boys	Girls
Infant Voc.	1.62	1.63	1.61
Infant Mov.	1.63	1.97	1.20
Infant Fret	1.62	1.64	1.60
Infant Play	.95	1.14	.73
Infant Noise	.65	.72	.56
Infant Smile	2.78	2.77	2.79

Figure Captions

Fig. 1. Behavior check list for one minute of observation.

Fig. 2. Summary data sheet listing accounting and nature of infant-mother behavior associations.

BEHAVIOR CHECK LIST - MOTHER-CHILD OBSERVATION

INFANT STUDY

Name Sarah M. Sex F Birth Date 8-26-70

Age 3 mos. Date of observation 12-11 Time 10 A.M. Observer PS

Situation in S's bedroom

Minute number 95

Infant	0-10	11-20	21-30	31-40	41-50	51-60
Eyes Closed						
Eyes open						
Vocalization		1	1			
Extra Movement						
Fret/cry						
Feed Self						
Quiet Play						
Noise/Non-voc						
Smile						2

* *

Mother	0-10	11-20	21-30	31-40	41-50	51-60
Touch					✓	✓
Holding						
Voc		2	2		1	1
Look		✓	✓			
Smile/Laugh						
Play w/S						
Change-diaper						
Give Bottle						
Rocks S						
Reading/TV	✓	✓	✓			
Other						

NAME ______________________

MATERNAL Behaviors

INFANT Beh.	freq	Touch	Hold	Voc	Look	Smile	Play	change	Feed or Bottle	Rock	Pacifier or toy	Voc to Others	Read or TV	Other
Voc														
Mov't														
Fret/Cry														
EAT														
PLAY														
Noise														
Smile														

END