Developmental Psychology
1987, Vol. 23, No. 2, 199–203

Sequential Analysis of Mastery Behavior in 6- and 12-Month-Old Infants

Robert H. MacTurk, Mary E. McCarthy, Peter M. Vietze, and Leon J. Yarrow
Child and Family Research Section
Laboratory of Comparative Ethology
National Institute of Child Health and Human Development

We examined the pattern and direction of behaviors that reflect infants' underlying mastery motivation. The sequences of mastery behavior were analyzed in a sample of 67 infants when they were 6 and 12 months old. We computed (a) the frequencies of each of six categories of mastery behavior, transitional probabilities, and *z* scores for each possible behavior change between the categories and (b) the transitions from a mastery behavior to an instance of positive affect. The analyses revealed significant age changes in the frequency of each category; however, the significant transitional probabilities among the six categories displayed a similar organization at both ages. The transitions from a mastery behavior to an instance of positive affect suggest that it is persistent, goal-directed behaviors that contribute to an infant's feeling of efficacy.

Our purpose is to examine the behavioral sequences of mastery behavior in a longitudinal sample of 6- and 12-month-old infants.[1] The underlying assumption is that all organisms are motivated to engage with and benefit from interactions with their environment. This assumption is one held by theorists from wide-ranging areas including Piaget (1952), Atkinson (1958), Hebb (1949, 1955), and Maslow (1954). Hebb (1949), in describing motivation, wrote that "the chief problem. . . . of motivation, is not arousal of activity but its patterning and direction" (p. 172).

Motivated behavior is exploration directed toward a specific goal. This notion is derived primarily from White's (1959) theoretical paper on effectance, or mastery motivation. Although White considered direction to be one of the defining characteristics of mastery motivation, he did not operationalize his key concepts. However, his description of direction as it pertains to mastery motivation provides a clue to an empirically testable definition as well as the appropriate analytic method. Direction was described as "constantly circling from stimulus to perception to effect" (p. 322), thus suggesting the need to preserve the sequences of infants' actions as they use various behaviors to engage with and extract information from objects. For the purposes of this report, therefore, we have defined direction in terms of both the specific behaviors that tap the infant's mastery motivation and the movement or transition from one behavior to another.

The aspect of direction pertains directly to the earlier work on mastery motivation (Yarrow et al., 1983) in which the infant's actions with objects were conceived of as representing a hierarchy. Visual attention, exploratory behavior, and persistence were considered (in order) to range from the most basic to the most sophisticated expressions of mastery motivation. We feel that the sequences that proceed from the more basic to the more sophisticated levels of behaviors correspond to the movement from perception to effect, whereby perception, broadly interpreted, is visual or manual exploration, or both, and effect is analogous to success.

The analytic technique that we used involved a detailed examination of the infants' behavioral sequences (i.e., lag sequential analysis) between the previously identified mastery behaviors. Though this technique is well established in the ethological literature (see Sustare, 1978) and has been applied to studies of human social interaction (Bakeman & Brown, 1977; Sackett, 1978; Vietze, Abernathy, Asche, & Faulstich, 1978), it has been used only recently in studies of object-related activities (MacTurk, Vietze, McCarthy, McQuiston, & Yarrow, 1985).

The measures that we used were drawn from the raw data and parallel those used by Yarrow et al. (1983) with three important differences. First, frequencies, rather than percentage duration, were used in order to provide independent estimates of the occurrence of each behavior. Second, the behaviors that constituted the Yarrow et al. (1983) off-task measure were separated into social and off-task categories. This decision was based on the results of two recent reports (MacTurk, Hunter, McCarthy, Vietze, & McQuiston, 1985; MacTurk, Vietze, et al., 1985) that suggested that the integration of social behaviors into the stream of object-related activities represents an important aspect of motivation. Last, success was included as a separate category in order to provide a measure of task completion.

We seek to extend the understanding of how infants organize their manipulative activities in the service of mastery motivation. We therefore reanalyzed the raw data on which the Yarrow et al. (1983) report was based in an effort to address the question

Correspondence concerning this article should be addressed to Robert H. MacTurk, Gallaudet College Research Institute, KDES PAS-9, Washington, D.C. 20002.

[1] The term *mastery behavior* refers to the infant's observed activity with objects. We feel that these behaviors reflect an underlying, intrinsic mastery motivational system that serves to instigate and maintain behaviors that promote learning. We conceptualized the overt expression of this motivational system as being primarily a state-dependent phenomenon in which the stimulus situation (task attractiveness, difficulty, incongruity, etc.) introduces some degree of error.

of direction of motivated behavior, as assessed via the pattern of behavioral sequences.

Method

Subjects

The longitudinal sample consisted of 67 firstborn infants (36 boys and 31 girls) who were from middle-income families with both parents present and whose births were free from complications. The mothers' mean age and education were 28 and 16 years, respectively, and the fathers' were 30 and 17 years, respectively. The infants were seen when they were 6 and 12 months old (±2 weeks).

Procedures

The laboratory assessments of mastery behavior were conducted in two sessions during which the infants were presented with twelve tasks for 3 min each, six tasks per session. The sequence of task presentation within a session was fixed but the order of the sessions was counterbalanced by sex and age.[2]

Each session was videotaped from behind a one-way mirror. We later coded the videotapes by using an electronic data recording device (Datamyte) and an exhaustive and mutually exclusive coding scheme that yielded a sequential record of each infant's behavior.[3]

These data were processed through a computer program that pooled the frequency of each behavior across the 12 tasks into the categories Look, Explore, Persist, Success, Social, and Off-Task, and then summed the number of transitions from one category to the next.[4] Transitional probabilities and z scores were computed for each possible transition for each child via the methods suggested by Bakeman (1979). The transitions from a mastery category (excluding Social and Off-Task) to an instance of positive affect (laughing or smiling) were also computed.

One may argue that some definitional dependencies in the coding scheme would preclude sequential analysis of these data. For example, because "success" with the Activator required a child to grasp and pull one of the balls to ring the bell, grasping and pulling (a Persist behavior on this task) must always precede an instance of success. However, each behavior required a minimum duration—the time required to enter the respective code into the Datamyte—in order to be considered a separate event. Therefore, if an infant quickly and smoothly engaged in a series of maneuvers that resulted in success, the intermediate Persist behaviors would not be coded. Nevertheless, we do recognize that at some microscopic level (for example, that of a frame-by-frame analysis), definitional dependencies might exist.

The measures that we used were the frequency of behaviors in each category (e.g., Look, Explore), the observed probability of each possible transition (i.e., Look to Explore, Look to Persist, Success to Off-Task, etc.), and the observed frequency of each transition from a category to an instance of positive affect.

Results

Reliability

We assessed interrater reliability by having two observers independently code approximately 20% of the videotapes. These estimates were computed on the transitional frequencies that occurred at levels greater than chance. At 6 months, Pearson product–moment correlations ranged from .67 to .93 with a mean of .82. At 12 months, the correlations ranged from .26 to .99 with a mean of .73. The lowest reliabilities at 12 months were for the transition from Social to Off-Task (.26) and from Off-Task to Social (.35); the remaining reliabilities were higher than .50.

Table 1
Means, Standard Deviations, and Age-Related Fs for the Frequency of Each Category of Mastery Motivation

	6 months		12 months		
Category	*M*	*SD*	*M*	*SD*	$F(1, 66)$
Look	42.82	18.52	55.79	31.46	9.62*
Explore	27.00	15.84	16.84	11.91	15.19**
Persist	167.63	58.24	138.92	50.82	9.08*
Success	107.85	44.04	74.46	33.46	28.41**
Social	18.16	11.66	38.91	22.42	45.88**
Off-task	32.48	20.89	12.91	10.63	46.29**

Note. $N = 67$.
* $p < .01$. ** $p < .001$.

Descriptive Analyses

The results are presented for the entire group because no significant sex differences were found in the means for any of the measures. The means, standard deviations, and the results of the post hoc tests for the frequency of each category are shown in Table 1. A 2 × 6 (Age × Category) analysis of variance (ANOVA) on repeated measures revealed significant main effects for age, $F(1, 66) = 6.46$, $p < .05$, and category, $F(5, 330) = 491.92$, $p < .001$. The Age × Category interaction was also significant, $F(5, 330) = 20.07$, $p < .001$. Post hoc Tukey analyses

[2] At 6 months, half of the male and female infants were administered the "A" series tasks on their first visit, and the other half were given the "B" series on their first visit. At 12 months, those male and female infants who were given the "A" series on their first visit at 6 months were given the "B" series first, and those infants who had been given the "B" series at their visit at 6 months were given the "A" series at 12 months.

[3] General descriptions of the tasks and coding scheme are contained in the report by Yarrow et al. (1983). Detailed accounts of the methods and coding criteria are contained in the report by Vietze et al. (1986).

[4] The coding scheme enabled us to assess individual behaviors (dropping, mouthing, looking at mother, etc.), which were determined, on an a priori basis, to constitute the subordinate categories of look, explore, manipulate, task-directed, goal-directed, success, social, and off-task. We formed the superordinate categories by summing explore and manipulate into Explore and task- and goal-directed into Persist. The rationale for this pooling was based on the similarities between the behaviors in explore and manipulate and task- and goal-directed, and is analogous to the distinction that Weisler and McCall (1976) drew between motor-aided perceptual examination and active physical interaction. Explore and manipulate were considered similar because of the general nature of the actions involved. Mouthing, touching, banging, and shaking were all behaviors that may be done with any toy and do not necessarily relate to particular toy properties. The task- and goal-directed categories, on the other hand, involved behaviors that were specific to that toy. For example, directly hitting the bell on the Activator (the first toy in Session A at 6 months) would be coded as task-related because it was directed toward the properties of that toy; batting would also attain the same effect, but because batting is a behavior that may be performed with any toy, it would not qualify as a persist behavior in this instance.

Table 2
Conditional Probability Means, Standard Deviations, and Significance Levels for the Infants at 6 and 12 Months

	Look		Explore		Persist		Success		Social		Off-task	
Category	6	12	6	12	6	12	6	12	6	12	6	12
Look												
M	—	—	.02	.02	.78**	.78**	< .01	< .01	.08	.14	.11	.05
SD			.03	.03	.11	.12	.00	.01	.08	.10	.08	.05
Explore												
M	.09	.13	—	—	.85**	.64*	.00	.00	.02	.20	.04	.03
SD	.06	.13			.11	.15	.00	.00	.05	.15	.06	.05
Persist												
M	.13	.19	.13	.08	—	—	.64**	.54**	.02	.15	.08	.03
SD	.06	.08	.06	.06			.09	.13	.02	.08	.06	.03
Success												
M	.03	.07	.04	.02	.90**	.86**	—	—	< .01	.04	.03	< .01
SD	.03	.07	.04	.03	.06	.08			.01	.04	.02	.01
Social												
M	.19	.29*	.01	.08	.18	.50	< .01	.03	—	—	.62**	.11*
SD	.17	.15	.04	.08	.14	.16	.00	.02			.22	.09
Off-task												
M	.25*	.36	< .01	.03	.38	.31	< .01	< .01	.36**	.30*	—	—
SD	.14	.24	.01	.07	.14	.26	.01	.00	.11	.21		

Note. The entries represent the conditional probability of going from a row to a column behavior; for example, for a 6-month-old infant, the probability of success being followed by persist was .90. The dashed lines on the diagonal represent a behavior following itself; because the event sequence analysis does not permit such an occurrence, these should be ignored.
* $z > 1.96, p < .05$. ** $z > 3.30, p < .001$.

for the simple effect of age revealed significant changes from 6 to 12 months. The frequency of look and social behaviors increased with age, whereas explore, persist, success, and off-task behaviors decreased in frequency over the same period. These results were consistent with the age differences reported by Yarrow et al. (1983) for similar categories of behavior expressed as percentage durations.

Sequential Analysis

Table 2 contains the means and standard deviations for all possible observed transitions among the categories of mastery motivation. Kinematic representations of these data appear in Figures 1a (6 months) and 1b (12 months). Only the transitions that occurred at levels significantly above chance ($z > 1.96, p < .05$) are represented in the figures. Those that occurred at levels significantly below chance ($z < -1.96, p < .05$) are not represented because they did not meet the minimum of at least 25 instances of the transition and an observed probability of at least .10 (Sackett, 1978).

The kinematic diagrams (Figures 1a and 1b) suggest that there is a strong pattern of similarities in the sequences at 6 and 12 months. Specifically, the common transitions at both ages were (a) from Look to Persist, from Persist to Success, and from Success to Persist, (b) a pattern of transitions between Off-Task and Social, and (c) a transition from Explore to Persist.

The only age-related difference emerged with regard to the relative role of social. When the infant is 6 months old, Social is most likely to be followed by Off-Task; when the infant is 12 months old, however, Social has a higher probability of being followed by Look, though it also precedes Off-Task a significant number of times.

Transitions to Positive Affect

Table 3 contains the means and standard deviations for the frequency of each transition from a look, explore, persist, or success behavior to an instance of positive affect. Because in this analysis we were primarily concerned with the infants' actions with objects, the transitions to positive affect that were preceded by a social or off-task behavior are not presented.

A 2 × 4 (Age × Category) ANOVA on repeated measures revealed significant main effects for age, $F(1, 66) = 37.70, p < .001$, and for category, $F(1, 198) = 60.10, p < .001$, as well as an Age × Category interaction, $F(1, 198) = 3.61, p < .05$.

The number of occurrences within each category increased from 6 to 12 months without any change in the categories' relative rankings. At both ages, the transition from Success to positive affect was the lowest and that from Persist to positive affect the highest.

Discussion

Our results support White's (1959) notion that mastery motivation may be characterized by direction, in addition to persistence. Specifically, the pattern of significant behavioral transitions as represented in Figure 1 suggests that at both 6 months and 12 months of age, infants focus their manipulative activities in a direction that leads them to the goal of successful task performance. This is evident not only from the significant probabilities associated with the transitions from Persist to Success, but also from the absence of any significant paths from the other categories of mastery motivation.

We also found that the infants in this sample displayed significant age changes in the various categories of mastery moti-

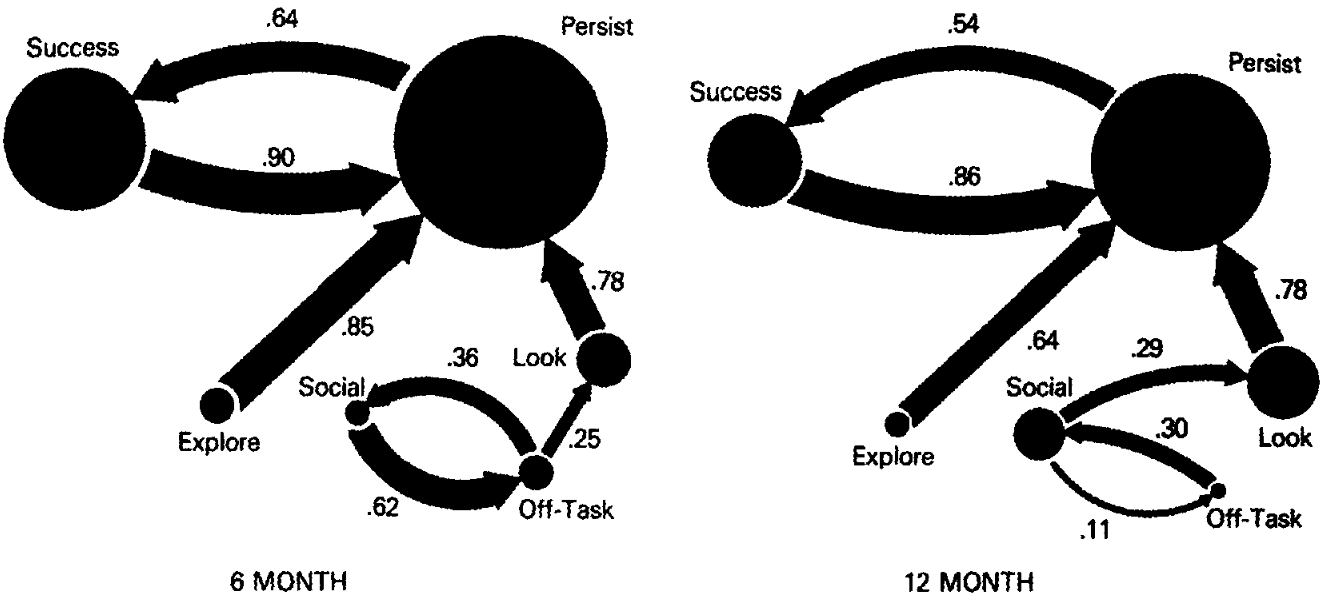

Figure 1. Kinematic diagrams of the transitions at 6 (part a) and 12 (part b) months of age. (The mean frequency of each category is indicated by the size of the respective circle. The thickness of the arrow represents the relative size of the transitional probability. The number next to the arrow indicates the mean transitional probability.)

vation. There were increases in the frequency of look and social behaviors at 12 months and decreases in the frequency of explore, persist, success, and off-task behaviors. These changes in frequency, however, were not reflected in the direction of their efforts. The only change revolved around the transitions from Social. With regard to the findings on the transitions to positive affect, it appears that the infants derive more pleasure from attempting to master the tasks than from actually solving them.

The ANOVA revealed that at 6 and 12 months of age, infants interacted with objects at different rates and that certain categories appeared to be particularly salient. Persist behaviors were by far the most frequent at both ages. It appears that task goal-directed activities were an important element in these infants' behavioral repertoires. Success, especially at 6 months, was also an important aspect of their repertoire.

The seemingly anomalous finding that occurrences of persist and success behaviors decrease with age may be a function of task differences and the difficulty in selecting tasks that are both conceptually and developmentally comparable across age. Although one may postulate that the 12-month tasks were either too easy or too difficult, it is also likely that the experimenter-defined criteria for these categories missed more sophisticated manipulative activities. Belsky and Most (1981) found that 12-month-old infants commonly engage in behaviors that according to our coding protocol would not be consistently categorized as either Persist or Success. An additional source of error may be that the older infants frequently attempted to obtain the other toys that were hidden behind a screen; although they would be exhibiting motivated behavior (i.e., direction and persistence), these attempts would be coded as Off-Task. This may have also contributed to difficulties in reliably coding the transitions between Off-Task and Social for the age of 12 months.

Though there were significant age changes in the overall frequency of each category of mastery motivation, these changes did not dramatically alter the pattern of transitions. There was a striking similarity at both ages in how the infants organized their attempts to master the objects; the only change revolved around Social. At 12 months, social behaviors seem to reflect an added dimension that was not evident at the earlier age. The older infants tend to follow social behaviors with look behaviors before going to persist behaviors, whereas at 6 months, social behaviors were not directly involved with task-related behaviors and do not seem to have the same salience in the context of attempting to master the environment. Because the computations involved in deriving the z scores corrected for the base rates, the difference in sequence was not a function of the difference in frequency.

The change in the significant transitions from social behaviors as well as the overall increase in their frequency suggests

Table 3
Means, Standard Deviations, and Age-Related Fs for the Transitional Frequency From a Category of Mastery Motivation to Positive Affect

	6 months		12 months		
Category	M	SD	M	SD	$F(1, 66)$
Look	0.99	1.27	4.52	4.71	38.39*
Explore	3.58	4.55	7.31	5.56	20.56*
Persist	5.49	5.81	10.43	9.03	120.60*
Success	0.88	1.31	2.84	3.44	22.71*

* $p < .001$.

that the relative importance of social behaviors in the context of mastery with objects changes during the last half of the first year of life. The older infant may be exhibiting a form of social referencing (Feinman, 1982) before engaging in the task again, whereas the younger child may not be as adept at integrating the social aspects of his or her behavioral repertoire into an ongoing stream of task-related activities.

With regard to the data on the transitions to positive affect, it may be that the behaviors that result in a feeling of efficacy are not the striving for success, nor success per se, but rather the transition from the striving to achieve a goal to its attainment. In short, it is the probability that persistence will pay off that motivates the child. The transitional frequencies from a mastery behavior to an instance of positive affect support this notion and also support the contention that positive affect is a powerful marker of cognitive processes (Harter, Shultz, & Blum, 1971; Kagan, 1971; Sroufe & Waters, 1976). Smiling and laughing were preceded most frequently by Persist and most infrequently by Success (see Table 3). If success consists of two elements—the first being the awareness that one can be successful and the second, achievement, serving as a confirmation of the first—then, to the extent that feelings of efficacy are accurately indexed by positive affective displays, one could expect positive affect to be associated with persistence rather than with success, an expectation supported by our data.

In summary, although we are confident that our methodology is reliable enough to enable us to assess the behaviors that reflect the infant's motivation to engage with and profit from interactions with the environment, we recognize some of its limitations. Future studies should address, in a more systematic manner, the problems associated with experimenter- versus child-defined motivated behaviors. A more detailed coding of off-task behaviors may facilitate capturing the full range of behaviors considered to be motivational in nature. This may also contribute to a more reliable assessment of how motivation directed toward the animate environment relates to other aspects of motivation.

References

Atkinson, J. W. (Ed.) (1958). *Motives in fantasy, action, and society.* New York: Van Nostrand.

Bakeman, R. (1979). *Analyzing event sequence data: Computer programs ESEQ and ELAG* (Tech. Rep. No. 11). Atlanta: Georgia State University, Social Development Laboratory.

Bakeman, R., & Brown, J. (1977). Behavioral dialogues: An approach to the assessment of mother–infant interactions. *Child Development, 48,* 195–203.

Belsky, J., & Most, R. K. (1981). From exploration to play: A cross-sectional study of infant free-play behavior. *Developmental Psychology, 17,* 630–639.

Feinman, S. (1982). Social referencing in infancy. *Merrill-Palmer Quarterly, 28,* 445–470.

Harter, S., Shultz, T. R., & Blum, B. (1971). Smiling in children as a function of their sense of mastery. *Journal of Experimental Child Psychology, 12,* 396–404.

Hebb, D. O. (1949). *The organization of behavior.* New York: Wiley.

Hebb, D. O. (1955). Drives and the C.N.S. (conceptual nervous system). *Psychological Review, 62,* 243–254.

Kagan, J. (1971). *Changes and continuity in infancy.* New York: Wiley.

MacTurk, R. H., Hunter, F. T., McCarthy, M. E., Vietze, P. M., McQuiston, S. (1985). Social mastery motivation in Down syndrome and nondelayed infants. *Topics in Early Childhood/Special Education, 4,* 93–109.

MacTurk, R. H., Vietze, P. M., McCarthy, M. E., McQuiston, S., Yarrow, L. J. (1985). The organization of exploratory behavior in Down syndrome and nondelayed infants. *Child Development, 56,* 573–581.

Maslow, A. H. (1954). *Motivation and personality.* New York: Harper.

Piaget, J. (1952). *The origins of intelligence in children.* New York: International Universities Press.

Sackett, G. P. (1978). Measurement in observational research. In G. P. Sackett (Ed.), *Observing behavior, Volume 2: Data collection and analysis methods* (pp. 25–44). Baltimore: University Park Press.

Sroufe, L. A., & Waters, E., (1976). The ontogenesis of smiling and laughter: A perspective on the organization of development in infancy. *Psychological Review, 83,* 173–179.

Sustare, B. D. (1978). Systems diagrams. In P. W. Colgan (Ed.), *Quantitative ethology* (pp. 275–312). New York: Wiley.

Vietze, P. M., Abernathy, S. R., Asche, M. L., & Faulstich, G. (1978). Contingency interactions between mothers and their developmentally delayed infants. In G. P. Sackett (Ed.), *Observing behavior: Theory and applications in mental retardation* (pp. 115–132). Baltimore: University Park Press.

Vietze, P. M., Pasnak, C. F., Tremblay, A., McCarthy, M. E., MacTurk, R. H., Klein, R. P., & Yarrow, L. J. (1986). Manual for assessing mastery motivation in 6- and 12-month-old infants. *Psychological Documents, 15*(2), 21. (Ms. No. 2714)

Weisler, A., & McCall, R. B. (1976). Exploration and play: Resume and redirection. *American Psychologist, 31,* 492–508.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review, 66,* 297–333.

Yarrow, L. J., McQuiston, S., MacTurk, R. H., McCarthy, M. E., Klein, R. P., & Vietze, P. M. (1983). The assessment of mastery motivation during the first year of life. *Developmental Psychology, 19,* 159–171.

Received April 1, 1985
Revision received January 6, 1986 ■