The Organization of Exploratory Behavior in Down Syndrome and Nondelayed Infants

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MacTurk, Robert H.; Vietze, Peter M.; McCarthy, Mary E.; McQuiston, Susan; and Yarrow, Leon J. *The Organization of Exploratory Behavior in Down Syndrome and Nondelayed Infants.* Child Development, 1985, **56**, 573–581. The exploratory behaviors of a sample of 11 infants with Down syndrome and 11 nondelayed infants, matched on Bayley mental raw scores and gender, were analyzed. Transitional probabilities and *z* scores were computed for each possible behavior change as well as frequencies of each behavior. The analyses revealed significant differences in how the 2 samples distribute their exploratory activities. The significant transitional probabilities among the 6 behavioral states revealed a pattern of similarities and differences. In general, both groups of infants organized their exploratory activities in a similar manner. However, there were differences that appeared to depend on the level of exploratory sophistication. The results are discussed in the context of the similarities and differences between the samples.

For a long time, exploratory behavior during infancy has been regarded as the centerpiece for the development of competence. Piaget (1952) saw exploration as an integrative process, while White (1959) considered it to be the mechanism by which infants express their motivation to master the environment. In a more empirical framework, McCall (1974) examined the developmental parameters of exploratory behaviors and, with his associates (McCall, Eichorn, & Hogarty, 1977; Weisler & McCall, 1976), demonstrated that early exploratory behaviors were an important contributor to later competence.

Recent studies have focused on extending McCall's (1974) notion that exploration is made up of discrete behaviors that follow a developmental progression toward greater sophistication and abstraction. Much of this work has been summarized by Belsky and his associates (Belsky, Garduque, & Hrncir, 1984; Belsky & Most, 1981), who developed a taxonomy that charts the development of exploratory behaviors through the first 2 years of life, from indiscriminate mouthing to sophisticated symbolic play.

The emphasis to date has been on defining age-characteristic modes of exploration and establishing their developmental sequence. What has not been examined is how infants organize their exploratory activities. Given that young infants display a variety of exploratory behaviors, what are the sequences of operations they employ to obtain information from inanimate objects? Though the analytic techniques for studying sequences of behavior are well established in the ethological literature (see Sustare, 1978) and have been successfully applied to studies of human social interaction (Bakeman & Brown, 1977; Vietze, Abernathy, Asche, & Faulstich, 1978), there remains a lack of data on the sequences of exploratory behavior in infancy.

We seek to extend understanding of exploratory behaviors during early infancy in the present study by examining the sequences of manipulative interactions with objects so as to shed light on the process by which infants engage with and extract information from objects. Infants were observed in a semistructured laboratory setting, and their exploratory behaviors were coded to obtain information on the transitions from one behavior to the next (i.e., lag sequential analysis). In addition, the behavioral organization shown by Down syndrome (DS) and nondelayed infants was compared. Previously reported work (McCarthy & Vietze, 1982; Vietze, McCarthy, McQuiston, MacTurk, &

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Yarrow, 1983) indicated that the two groups exhibit similar distributions in the relative amounts of time spent in the various levels of exploration, but that the amount of time spent engaged in two subcategories of exploration, Persist and Success, was systematically depressed in the DS sample. However, these results were based on chronological age-matched samples; the observed differences could have been confounded by differences in developmental status. In the present study, the two samples were matched on the Bayley Scales of Infant Development (BSID) (Bayley, 1969).

In sum, the goal of the study was to examine the distribution of behaviors of DS and nondelayed infants while they explore objects in order to identify the similarities and differences in how the two groups organize their exploratory activities.

Method

Sample.—The subjects of this report were 11 infants with Down syndrome and 11 nondelayed infants. The parents' mean ages were 32.2 and 33.3 for, respectively, mothers and fathers of the DS infants, and 26.3 and 27.5 for the mothers and fathers of the nondelayed group. Parents of DS infants had an average of 14.0 (mothers) and 15.4 (fathers) years of education; for the nondelayed group, these figures were 15.8 and 16.1. There were four firstborns and seven later-borns in the DS sample; all the nondelayed infants were firstborns. The two groups were matched on the Bayley mental scale raw scores; the mean chronological ages of the delayed and nondelayed infants were 9.2 and 6 months, respectively, and the mean Bayley mental raw score was 74.4 for both groups. There were an equal number of boys (5) and girls (6) in each group. The DS infants were diagnosed by cytogenetic analysis as possessing the Trisomy-21 variant of Down syndrome. They were living at home, from middle-income families, and were enrolled in early intervention programs. None of the infants in either sample suffered from any obvious sensory or motor impairments, and all were in good health.

The base population from which the two samples were drawn consisted of 75 nondelayed 6-month-old infants and 19 DS infants, aged 8 and 12 months. The matching was performed by ranking the DS infants by their BSID mental raw scores and then selecting a 6-month-old nondelayed infant whose score equaled (± 1 point) that of a delayed infant. In addition, the children were matched on the basis of sex. The resulting delayed sample consisted of seven 8-month-old and four 12-month-old infants.

Procedures.—The nondelayed infants had participated in a longitudinal study of the development of mastery motivation at 6 and 12 months of age (see Yarrow et al., 1983). The infants with Down syndrome had participated in a partial replication of the original study (Vietze et al., 1983). The nondelayed infants were given a different series of tasks at each age, while the DS sample was seen at either 8 or 12 months of age and given the series of tasks used with the 6-month-old nondelayed infants.

Exploratory behavior and developmental status assessments were conducted in testing rooms at our laboratory by different examiners. On the first session, the BSID were administered. The next two sessions consisted of the exploratory behavior assessments; the infants were presented with 12 tasks, six per session (Table 1). These tasks primarily involved exploration of commercially available toys. The procedures are described in detail elsewhere (Vietze et al., 1981). Each session consisted of six toys presented in a fixed sequence for 3 min each; the order of the sessions was counterbalanced by infant sex.

The sessions were videotaped from behind a one-way mirror. These videotapes were subsequently coded using a Datamyte (Electro-General Corp., Minnetonka, MN). The exhaustive and mutually exclusive coding scheme (Table 2) divided the infant's behavior into six levels: level 0 consisted of only looking at the toy or object; level 1 involved minimal contact with the toy (passive holding, touching, mouthing); level 2 included basic active exploration of the toy (hitting, banging, shaking); level 3 involved task-related behavior (exploration appropriate to the specific toy); level 4 was goal-directed behavior (actions directed toward mastering the task); level 5 was successful completion of the task.[1] In addition, two non-task-related behaviors were coded: off-task behaviors, and social behaviors directed toward mother, examiner, or the infant's image in the mirror.

The individual behavior codes were categorized as exploratory in nature according

[1] In a previous report (Yarrow et al., 1983), "offer, give," and "reject" (codes 87 and 86, respectively) were classified as instances of manipulative behaviors. In light of the strong social component contained in these behaviors, it was decided to recode them under the category of Social.

TABLE 1

TASKS FOR ASSESSING EXPLORATORY BEHAVIOR IN ORDER OF PRESENTATION BY SESSION

Task Name	Description	Definitions of Persist (P) and Success (S) Categories
Session A:		
Activator	An apparatus consisting of two small balls on strings, which, when pulled, causes a lever to hit a bell or hollow cylinder. It is hung on a boom stand in front of the infant.	(P) Touch, hit, or hold balls, bell, or knocker. (S) Ring bell.
Toy behind barrier	A lion squeeze toy is placed behind a clear plastic rectangular barrier. The child can obtain the toy by reaching.	(P) Hit, hold, or reach behind barrier. (S) Get toy.
Three men in a tub	A yellow plastic bucket containing three toy men who can be removed from the holes in which they are placed.	(P) Shake, grasp, or tip tub. (S) Get man out of tub.
Chime ball	A transparent spherical toy containing small toy animals that move and make noise when the ball is hit or rolled. It has been attached to a red ring base for stability.	(P) Grasp with two hands, push, or shake. (S) Make bell or horses move.
Snail	A brightly colored plastic animal on wheels, attached to a string. The infant can obtain the toy by pulling the string.	(P) Hold or reach for snail; pull string. (S) Pull string to get snail.
Objects in a tub	A red plastic bucket containing a variety of small plastic toys that can be removed.	(P) Shake, grasp, or tip tub. (S) Get object(s).
Session B:		
Busy bubble	A transparent spherical toy containing a butterfly and small colorful balls that spin about when the bubble is hit or pushed.	(P) Grasp, hit, or shake. (S) Make balls move.
Toy on a pad	A squeeze toy placed out of reach of the infant on a blanket. The infant can obtain the toy by pulling the blanket.	(P) Grasp pad or lion; reach for lion; pull pad. (S) Pull pad and get lion within reach.
Peg board	A yellow plastic board containing six removable pegs.	(P) Finger board; hold base, or peg over base; grasp peg(s). (S) Pull peg out.
Activity center	A rectangular board containing dials and levers that produce sounds and color when manipulated.	(P) Hold board or manipulandum; hit, push, etc.; appropriate manipulandum. (S) Produce effect.
Object permanence	One tan and one white cloth are used to cover small plastic toys in a series of steps adapted from the Uzgiris-Hunt object permanence assessment procedures.	(P) Reach for object or either cloth; pick up wrong cloth. (S) Uncover and get object.
Eggs in a carton	A blue plastic carton containing 12 white plastic eggs that can be removed.	(P) Hold, lift, shake, open, or tip carton. (S) Get one or more eggs from carton.

TABLE 2

LABORATORY BEHAVIOR CODES

Measure	Level	Code	Behavior
Look..........	0	00	Only look at apparatus
Explore	1[a]	11	Only touch apparatus
		12	Only mouth apparatus
		13	Only passively hold apparatus
	2	21	Manipulate
		22	Examine
		23	Bang
		24	Shake
		25	Hit or bat
		26	Drop object
Persist	3	31	Task-related behavior
		33	Grasping or holding
		34	Reach for apparatus
	4	41	Goal-directed maneuver
		42	Resets problem or task
Success	5	51	Effect produced
		52	Problem solved
		53	Motor task accomplished
Social.........	8	80	Looks at experimenter
		81	Vocalizes to experimenter
		82	Looks at mirror
		83	Looks at mother
		84	Vocalizes to mother
		85	Leans back on mother
		86	Reject object
		87	Offer, give
Off-Task	9	95	Engaged with non-task object
		99	Other

[a] Excludes looking at object.

to whether the infant was engaged either visually or physically with the object. The social and off-task behaviors were defined by the absence of co-occurring object-related activities. Looking or vocalizing to the experimenter or mother were coded as social only if they either included an affective component or occurred when the infant was not engaged with a toy. Looking at the mirror was considered to be a social behavior rather than off-task because the infant could see the reflections of the experimenter and mother as well as him/herself (it was, of course, not possible to determine what the infants were focusing on when they looked in the mirror).

The coding scheme permitted the collection of a sequential record of the infant's specific actions with each task. The raw sequential data were processed through a computer program that pooled the frequency of each behavior into the categories of Look, Explore (the sum of levels 1 and 2), Persist (the sum of levels 3 and 4), Success, Social, and Off-Task. The frequency of each possible transition was then computed among these six behavioral states.

The rationale for pooling levels 1 and 2 into Explore, and levels 3 and 4 into Persist, was based on the similarities between the behaviors in levels 1 and 2, and levels 3 and 4, and it is analogous to the distinction that Weisler and McCall (1976) have drawn between motor-aided perceptual examination and active physical interaction. The behaviors that constituted the two lower levels were considered to be similar because of the general nature of the actions involved. Mouthing, touching, banging, and shaking are all activities that may be performed with any toy and do not necessarily relate to particular toy properties. The two higher levels, on the other hand, involved behaviors that were specific to each toy. For example, directly hitting the bell on the Activator would be coded as task-related behavior because it was directed toward the properties of that toy; batting at the Activator could attain the same effect, but because batting is a behavior that may be performed with any toy, it would not qualify for a "Persist" code in this instance. The behaviors defining Persist and Success for each task are included in Table 1.

It may be argued that some definitional dependencies in the coding scheme would preclude sequential analysis of these data. For example, since "Success" with the Activator required the 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 event 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.

Transitional probabilities and z scores were computed for each possible transition for each child using the methods suggested by Bakeman (1979). The measures were the frequency of each behavior, the observed probability of each behavioral transition, and the z scores; these were computed across all 12 tasks.

Results

Reliability.—Rater reliability was assessed by having two observers independently code approximately 25% of the videotapes. Pearson product-moment correlations for the separate behaviors ranged from .53 to .94, with a mean of .80.

Descriptive analysis of the measures of exploratory behavior.—The means, standard deviations, and the results of the post-hoc tests for the frequency of each behavior are shown in Table 3. The results of the 2 (group) × 6 (categories of behavior) ANOVA revealed a nonsignificant main effect for group, $F(1,20) = 1.46$, N.S., a significant main effect for behavior, $F(5,100) = 82.06$, $p < .001$, and a significant group × behavior interaction, $F(5,100) = 6.78$, $p < .01$. The results of the post-hoc tests indicated that the nondelayed sample displayed a significantly greater number of exploratory and social behaviors, while the DS infants looked at the toys more frequently. The difference between the two samples was not in the total amount of behavior but rather in its distribution.

The values of the transitional probabilities for all possible transitions and z scores are contained in Table 4. Kinematic representations of the transitions that occurred significantly above chance ($z > +1.96$, $p < .05$) are presented in Figure 1*a* and 1*b*. The transitions significantly below chance ($z < -1.96$, $p < .05$) are not represented because they did not meet the minimal criteria of at least 25 instances of the transition and an observed probability of at least .10 (Sackett, 1978).

The pattern of transitions for the nondelayed infants (Fig. 1*a*) shows that Look, Social, and Success all tended to be followed by Persist. Further, the children tended to cycle back and forth from Persist to Success, although there were also a significant number of transitions from Success to the comparatively simpler Explore behaviors. Social be-

TABLE 3

MEANS, STANDARD DEVIATIONS, AND *F* RATIOS FOR THE FREQUENCY OF EACH MASTERY BEHAVIOR

	DS		NONDELAYED		
	M	SD	*M*	SD	*F*
Look	72.64	17.97	48.54	23.06	7.47*
Explore	46.27	17.53	69.18	20.64	7.87*
Persist	159.54	56.56	191.27	46.18	2.08
Success	105.54	45.85	100.36	32.92	.09
Social	23.00	30.79	75.91	30.25	16.53**
Off-Task	43.64	21.14	31.64	17.12	2.14

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

TABLE 4

Conditional Probability Means, Standard Deviations, and Significance Levels for the DS and Nondelayed (ND) Infants

	Look		Explore		Persist		Success		Social		Off-Task	
	DS	ND	DS	ND	DS	ND	DS	ND	DS	ND	DS	ND
Look	. . .	. . .	.08	.09	.60**	.64**	.00	<.01	.10*	.14	.22	.12
			.03	.02	.16	.14	.00	.01	.07	.10	.15	.08
Explore	.30**	.12	. . .	. . .	.48	.53	<.01	<.01	.08	.28*	.13	.07
	.09	.06			.12	.13	.01	.01	.11	.14	.11	.04
Persist	.14	.11	.12	.14	. . .	. . .	.64***	.52***	.03	.16	.07	.06
	.08	.05	.03	.04			.11	.11	.04	.05	.03	.04
Success	.06	.03	.20	.28**	.70***	.64**	. . .	. . .	.01	.02	.03	.03
	.03	.02	.10	.05	.13	.06			.02	.02	.03	.03
Social	.42	.07	.05	.11	.27	.73***	.00	.03	. . .	. . .	.26*	.06
	.36	.07	.06	.05	.21	.09	.00	.03			.31	.04
Off-Task. . . .	.52***	.17	.07	.06	.28	.32	.00	.00	.12	.45***	. . .	. . .
	.15	.15	.06	.06	.12	.08	.00	.00	.14	.13		

Note.—The entries represent the conditional probability of going from a row to a column behavior; e.g., for a DS infant, the probability of Success being followed by Persist was .70. The leaders on the diagonal represent a behavior following itself; since the event sequence analysis does not analyze such an occurrence, these should be ignored.

* $z > 1.96$, $p < .05$.

** $z > 2.58$, $p < .01$.

*** $z > 3.30$, $p < .001$.

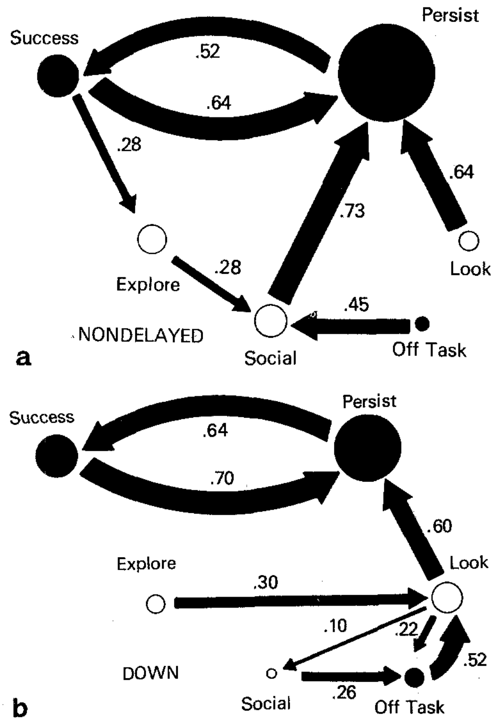

FIG. 1.—Kinematic diagrams of the exploratory behavior transitions for the nondelayed (*a*) and DS (*b*) samples. The mean frequency of each behavior is indicated by the size of the circle representing that behavior. Open circles represent a significant difference between the samples. The thickness of the arrows represents the relative size of the transitional probabilities. The numbers next to the arrows indicate the mean transitional probability.

haviors seem to constitute a salient element of the nondelayed children's behavior in that both Off-Task and Explore tended to be followed by Social, which was followed by a return to Persist.

Certain aspects of the behavior of DS infants were very similar to those of their nondelayed peers (see Fig. 1*b*). There was the same high probability of Look being followed by Persist, and the same cycling phenomenon between Persist and Success. However, the transitions between the less sophisticated level of Explore as well as of Off-Task and Social differed in that the DS infants tended to return to Look after an instance of Off-Task or Explore. Furthermore, the transitions to and from Look were less variable, that is, more of them were accounted for at above-chance levels. Note that each row total in Table 4 equals 1.00 (with an allowance for rounding errors), thereby accounting for 100% of the behavioral transitions. For the DS infants, 92% of the transitions from Look were accounted for by significant transitional probabilities, with the remaining 8% representing random transitions. For the nondelayed infants, only 64% of these transitions were accounted for by significant probabilities; the remaining 36% represents an over fourfold increase in random transitions when compared to the DS infants.

Discussion

In summary, the results of these analyses are supportive of two major conclusions. First, the two groups of children did not differ in the total amounts of behavior but, rather, varied considerably in the distribution of behavior. These differences were most evident in the amounts of looking and social behaviors engaged in by the delayed infants. Second, the patterns of behavioral transitions revealed striking similarities in the manner in which both groups mastered the tasks. The major differences between the two groups revolved around the transitions to and from looking. These differences in the patterns of behavior combined with the differences in the overall amounts of looking may indicate that the psychological meaning of looking may be different for the two groups.

Both Down and nondelayed infants were found to organize their attempts to explore the inanimate environment in a similar fashion, as evidenced by the high transitional probabilities associated with a return to Persist from the other behaviors. Persistent, goal-directed behaviors were an important aspect of these infants' behavioral repertoire, regardless of their presumed differences in cognitive capabilities. Both groups were characterized by a back-and-forth cycling between Persist and Success. Such cycling may represent either an example of secondary circular reaction or be indicative of perseveration, in which case the psychological meaning would be very different. However, differences in the manner in which the tasks were approached were seen when the behaviors going to and from Look were considered. There was only one significant transition associated with Look for the nondelayed infants, a transition to Persist. This behavior appears to serve as a "jumping off" point or initial behavior that was followed by a high level of task involvement. The DS infants tended also to go from Look to Social or Off-Task behavior a significant number of times, as well as to return to Look after Explore or Off-Task. It seems that Look was the hub of behavior organization for these children, a finding which may be due to the characteristic hypotonia associated with DS, or reflect more basic differences in central nervous system integrity, in that Down syndrome children may require more visual processing time to obtain the same information their nondelayed peers obtain in a shorter time. Support for this contention comes from visual preference experiments in which DS infants typically spend considerably more time examining visual stimuli than do nondelayed infants (Miranda & Fantz, 1973).

If looking was the hub of behavior for the DS infants, then Social behavior was the hub for the nondelayed infants. A significant number of transitions occurred from both Off-Task and Explore to Social, and to Persist. It could be that the nondelayed infants were seeking social reinforcement prior to engaging with the mastery tasks again, while the delayed infants were not as bound to elements of their social environment. Indirect support for this speculation comes from an earlier study of the relations between social responsiveness in 3-month-old DS infants and their on- versus off-task behaviors at 12 months of age. The DS infants who displayed greater early social responsiveness were more likely to make transitions that would either keep them on-task, or return them from an off-task to an on-task behavior, whereas the less socially responsive infants were more likely to go to an off-task behavior (MacTurk & McQuiston, 1982). This finding suggests that the ability to discern social cues is important in maintaining the child's involvement with the inanimate environment.

We recognize the limitations inherent in such a small sample of infants. However, this study provided important insights into the strategies infants adopt in their efforts to obtain information from the inanimate environment. Furthermore, it suggests that future investigations into the sequencing of exploratory activities with tasks that place a variety of specific demands upon infants' capabilities would expand our understanding of the development of competence.

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