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Learning in Premature Infants

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This study examined instrumental learning in premature infants by using a teddy bear that "breathed" quietly at a rate that reflected the infant's respiration rate. At 33 weeks conceptional age (CA), 45 infants were provided either a Breathing Bear (BrBr) or a Nonbreathing Bear (N-BrBr). The baby was monitored by time-lapse video for 3-day periods at the beginning and end of a 2-week intervention period. The BrBr babies decreased their latency to contact the bear over time, whereas the N-BrBr babies showed the opposite pattern. For the BrBr babies, decreased contact latencies were correlated with increased total contact and increased contact frequencies. Thus, by 35 weeks CA, premature infants learned to find and make contact with a reinforcing source of stimulation.

The capacity for learning by full-term newborns has been well established in classical conditioning (e.g., Blass, Ganchrow, & Steiner, 1984), operant conditioning (e.g., DeCasper & Fifer, 1980), and hybrid conditioning (e.g., Papousek, 1967) paradigms. Learning in prematurely born infants has not been studied except at postterm ages (Krafchuk, Tronick, & Clifton, 1983; Rose, Gottfried, & Bridger, 1979; Sigman, Kopp, Littman, & Parmalee, 1977; Sigman & Parmalee, 1974). The present study investigated learning by premature infants of 35 weeks conceptional age (CA). The instrumental response to be learned was directional motility, which permitted the infant to locate and attain contact with a reinforcing object.

Considerable evidence support the expectation of learning at this early age. Casual observations of learning during the preterm period have been reported (Solkoff & Cotton, 1975). Barnard and Bee (1983) reported that premature infants who benefitted most from an intervention were those who experienced both contingency and temporal patterning of stimulation. In addition, learning by the fetus during the late intrauterine period was demonstrated by DeCasper and Fifer (1980), who found that newborn infants showed a preference for their mothers' voice even though they had limited exposure to her voice before testing. In animal studies, Smotherman and his colleagues (Smotherman, 1982; Smotherman & Robinson, 1987; Stickrod, Kimble, & Smotherman, 1982) demonstrated prenatal learning in the fetal rat by classically pairing a novel taste–odor conditioned stimulus with lithium chloride injections and observing postnatal aversion to the stimulus.

Studies of learning by preterm infants have not been undertaken because the fragility of these infants precludes most experimental interventions as potentially stressful to them. They are highly susceptible to overstimulation and can show physiological decompensation to even routine handling (Sehring, Gorski, Sweet, Martin, & Leonard, 1985). The paradigm used for this study was designed so as to avoid the risk of stressing the infants by involving a directional motor response and by using a form of stimulation that was (a) not imposed on the baby—the infant could regulate the amount of stimulation—and (b) already demonstrated to have a positive valence for preterm infants (Thoman & Graham, 1986; Thoman & Ingersoll, 1988, 1989; Thoman, Ingersoll, & Acebo, 1988).

Operant conditioning of young organisms is considered to be most successful when low-energy responses that do not habituate are used as criterion behaviors (Rovee-Collier & Lipsitt, 1982). The use of low-energy responses mitigates against fatigue as a source of interference in training. Although motor activity per se is not a low-energy behavior, we considered directional motility to be appropriate for this study because baseline motor activity is typically high across behavioral states in prematures (Krafchuk et al., 1983), and little additional energy should be necessary to effect a directional change.

The reinforcing stimulus for this study was the tactile, kinesthetic stimulation from a "breathing" teddy bear placed in the isolette beside the infant. The infants could touch or cuddle the bear, or they could move away from it. The bear's breathing rate was based on that of the individual infant it was with, so that the stimulation reflected one of the infant's own biological rhythms. This choice of rate was made to individualize the stimulation, because there is no evidence for the appropriateness of specific rhythms for premature infants.

The Breathing Bear is made to "breathe" gently by means of a pump outside the isolette, which is connected to the bear through a plastic hose, making the bear's torso expand and contract quietly to mimic the smooth sinusoidal breathing of a healthy infant during quiet sleep. Continuous availability of the

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bear can be considered a free-operant conditioning paradigm, with immediate contingent reinforcement. This arrangement was designed to avoid the overstimulation that might characterize a fixed-trials approach to conditioning in prematures (Rovee-Collier, 1987).

As indicated, the bear was specifically designed to breathe quietly. From the perspective of the welfare of the infants, this was important to avoid overstimulating them with a constant auditory input. From the perspective of research design, the quiet breathing avoided the presence of a sound gradient as a possible cue to the location of the bear.

In previous studies (Thoman & Graham, 1986; Thoman & Ingersoll, 1988, 1989; Thoman et al., 1988), we found that, after a 2-week intervention period from 33 to 35 weeks CA, preterm infants showed significantly more contact with a Breathing Bear than with a Nonbreathing Bear or with the space in the isolette that would have been occupied by a bear. In addition, infants who had the Breathing Bear intervention showed more mature sleep patterns subsequently in terms of more quiet sleep at 35 weeks CA and during the first 5 postterm weeks. These findings indicated that experience with the Breathing Bear facilitated neurobehavioral maturation that was measurable 5 to 10 weeks after exposure to the bear.

Our previous studies were focused on demonstrating the infants' preference for Breathing Bears and the developmental consequences of this early experience. However, we speculated that the infants with a Breathing Bear were learning to approach and find the Bear as a source of rewarding stimulation. The present study was carried out to test this hypothesis. To make such a test, we had to replicate our previous results with the Breathing Bear and to eliminate potential sources of bias by assessing a number of variables that might be related to the babies' responses to the bear. It is not possible, in a neonatal intensive care unit, to arrange for and maintain the many controls that would ideally be appropriate for a conventional learning study. Thus, the goal of this study was to demonstrate the emergence of individual differences that were consistent with a learning interpretation of changes in the babies' behaviors during the 2-week intervention period.

Method

Subjects

The subjects were 58 premature infants born at or transferred to three regional hospitals with Level III neonatal intensive care units (NICUs) and were followed if they were transported to any of four outlying hospitals. Infants were eligible for the study if, by 33 weeks CA, they were free of mechanical ventilation, did not require treatment for multiple prolonged apneas, were without known neurological dysfunction, and were considered to be physiologically stable by the attending physician.

Successive pairs of infants were randomly assigned within each hospital to either a Breathing Bear (BrBr) or Nonbreathing Bear (N-BrBr) group. Of those enrolled, 2 infants (both BrBr) had recurrent medical problems, 5 (3 BrBr and 2 N-BrBr) had to be dropped because of inadvertent interference by the nursing staff with the recording equipment, and 4 (all N-BrBr) were transported to another hospital before we initiated procedures for continuing the study in outlying hospitals. Two additional infants (1 BrBr and 1 N-BrBr) were dropped after serving as subjects because data analysis from the videotape scoring indicated that they had been restrained by blanket rolls or had been swaddled more than 90% of the time during the final 3-day observation period. Clearly, they had little opportunity to move to the bear.

Of the remaining 45 infants, there were 13 male infants and 10 female infants in the BrBr group and 9 male infants and 13 female infants in the N-BrBr group. Demographic characteristics of the two groups are presented in Table 1. Gestational age at birth (GA) was determined as postconceptional age by the attending physician at the time of delivery. The groups did not differ on any of the demographic variables.

Equipment

We designed time-lapse video equipment that fit onto the infant's isolette. The camera was suspended over the isolette from a pole attached to the side of the isolette, and the VCR and power supply were placed on a rolling platform that was attached underneath the isolette (see Figure 1). Thus, the recording system did not require floor space in the NICU, the isolette was completely mobile during videorecording, and infant caregiving was not obstructed by the recording procedure.

The bears were made of blue-dyed sheepskin and were designed to present a uniform ventral profile to the infant; hence the infant could attain contact with the bear's abdomen without being impeded by its snout or limbs. If the infant was assigned a Breathing Bear (U.S. Patent No. 4,606,328), a rubber bladder inside the bear (specially designed to mute the sound of airflow) was connected by plastic tubing to a lightweight pump placed on a shelf beside the isolette. The pumps were custom-engineered by Harvard-Ealing Co. (South Natick, Massachusetts) to function very quietly, to produce a sinusoidal "respiratory" waveform for the bear, and to simulate the breathing pattern of a healthy neonate during quiet sleep. Sound from the bear's breathing was audible only if an adult's ear was pressed firmly against the bear's torso. Thus, it was not expected that the bear's sound level could provide a directional cue to the babies.

The pump's rate and volume were adjustable. Infants assigned a Nonbreathing Bear received an identical bear that was not connected to a pump.

The inside dimensions of the isolette were 15.75 × 33.5 in. (40 × 85 cm). The bear was placed on its side against the back wall of the isolette to occupy minimal space, and it covered an area of 3.5 × 12 in. (8.9 ×

Table 1
Demographic Characteristics of the Infants in the Breathing Bear and Nonbreathing Bear Groups

Variable	Breathing Bear *M*	Breathing Bear *SD*	Nonbreathing Bear *M*	Nonbreathing Bear *SD*
Birth weight (g)	1,125.1	273.3	1,147.1	221.3
Gestational age (wk)	28.8	2.4	28.8	1.9
Maternal age (yr)	27.1	5.7	27.0	5.3
Conceptional age at enrollment (wk)	32.7	1.1	32.6	1.3
No. of days with bear	21.7	8.3	24.3	9.1
Obstetric complications[a]	10.7	4.0	11.7	2.4
Neonatal complications[b]	3.9	1.7	4.4	1.8

Note. Sample sizes are 13 male infants and 10 female infants in the Breathing Bear group and 9 male infants and 13 female infants in the Nonbreathing Bear group.
[a] Scored on Prechtl (1968) scale. Possible number of nonoptimal events ranged from 0 to 42. [b] Scored on Postnatal Complications Scale (Littman & Parmalee, 1978). Possible number of nonoptimal events ranged from 0 to 10.

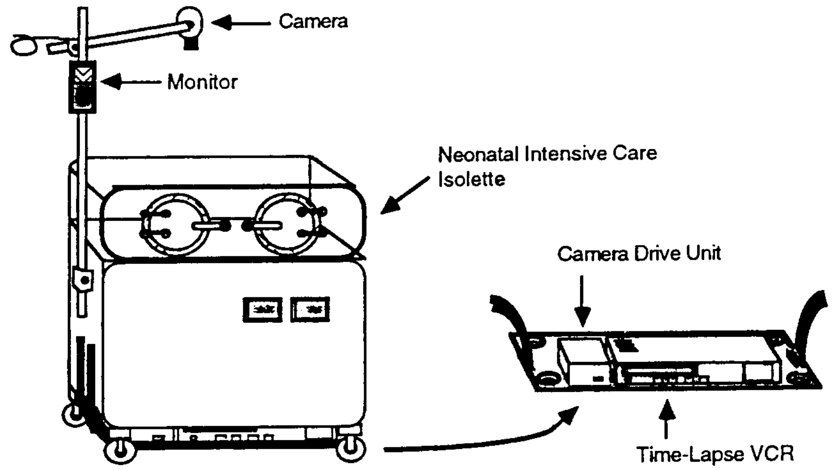

Figure 1. Video recording equipment used on the isolette. (From "Premature Infants Seek Rhythmic Stimulation, and the Experience Facilitates Neurobehavioral Development" by E. B. Thoman, E. W. Ingersoll, and C. Acebo, 1991, *Developmental and Behavioral Pediatrics, 12,* p. 13. Copyright 1991 by Williams & Wilkins. Reprinted by permission.)

30.5 cm). Thus, there was sufficient room for infants to touch or to be away from the bear.

General Procedure

The parents were interviewed for consent as soon as their premature infant was physiologically stable. Then, depending on the infant's group assignment, a Breathing Bear or a Nonbreathing Bear was placed in the isolette. Instructions to the nurses were that, at the end of each caregiving or medical intervention, they were to place the infant in the middle of the sleeping area within the isolette, but they were not to place the baby in contact with the bear.

Because the learning task for the infants was to move to the bear and achieve contact, the position of the bear in the isolette was not changed. These immature babies, at 2 to 3.5 pounds, would never have found the bear if it had been moved to varied locations in the isolette. However, we had found in a preliminary study that whether the bear was put at the front or the back of the isolette made no difference in the amount of contact, as long as it remained in one place. For this study, the bear was put along the back sidewall of the isolette to avoid interference with caregiving and necessary medical procedures.

We did not include a no-bear condition because in a previous study (Thoman & Graham, 1986), we did not find differences in contact or other outcome measures as a function of whether the babies had a nonbreathing bear or no bear in the isolette. For the no-bear babies, we assessed the babies' contact with the area (marked when scored on the video screen) that a bear would occupy.

When the Breathing Bear was placed in the isolette, the baby was observed during quiet sleep, and quiet-sleep respiration rate was determined. Then the pump was set to make the bear breathe at one half of the baby's rate. The half rate was used, as it has been in each of our previous studies, because some of the prematures breathe as fast as 60 breaths per minute, and this rate was subjectively judged by parents and nurses to be too fast to be appropriate stimulation for a premature baby. Although maternal rates have frequently been used for stimulating premature infants, we based our design on the assumption that the infant's own rhythms should be the safest, and possibly the most appropriate, as reinforcement for the infants (Thoman & Ingersoll, 1989; Thoman, Ingersoll, & Acebo, 1991).

As soon as a bear was placed with an infant, we began continuous time-lapse video recording using a rate of 60:1. Twenty-four hour recording continued for the duration of the intervention, which lasted until the baby graduated from the isolette to a nursery crib.

For this study, the time-lapse videotapes were scored over two 3-day periods, at 33 and 35 weeks CA. All measures were mean values over each of the 3-day periods. These two ages were selected because they provided a 2-week window of time when the greatest number of subjects could be included. Twelve days with a bear was defined as the minimum intervention period. Some babies were given a bear before 33 weeks CA, but the subjects in the two groups did not differ with respect to how long they had the bear before the first video recordings: $M = 7.5$ days ($SE = \pm 2.7$) for the 4 babies in the Breathing Bear group and $M = 7.4$ days ($SE = \pm 3.2$) for the 5 babies in the Nonbreathing Bear group.

Variables and Measures

Behaviors recorded from the videotapes. The videotapes, recorded at a 60:1 ratio, were dubbed with an audio signal to create 5-s epochs for scoring. Each 5 s on tape corresponded to 5 min of real time. The tapes were scored in these 5-s (i.e., 5-min) epochs for the following variables:

Contact: Some part of the baby's body was touching the bear (did not include periods when the nurse put the baby down in contact with the bear after caregiving).

Latency to contact bear: The number of epochs from the end of a caregiving period until the onset of contact.

Baby alone: No caregiving was ongoing and nothing obstructed the camera's view of the baby.

Baby restrained: The baby was propped with a blanket roll or was swaddled.

Caregiving: Epochs when the nurse was engaged in a medical procedure or any form of caregiving (feeding, bathing, etc.) while the baby was in the isolette.

Baby available: The baby could be viewed in the isolette, was alone, and was not restrained.

Waking: The baby was actively moving, was crying, or was quiescent with the eyes open.

Active sleep: The baby was intermittently quiescent and the eyes were closed, with rapid eye movements and twitches or jerky movements of the extremities.

Quiet sleep: The baby was generally quiescent, with occasional startles or other brief motor movements.

Each of these variables was recorded if it occurred for more than half of the epoch. For example, contact was scored for an epoch only if it occurred for more than half of the 5-s (5-min real-time) epoch.

Measures of behaviors recorded from the videotapes. For each 3-day period (i.e., when the infants were 33 and 35 weeks CA), the following measures were obtained:

Total contact: Amount of time spent in contact, measured as a percentage of baby-available time.

Frequency of contact bouts: Number of periods of contact per hour of baby-available time.

Bout lengths of contact: Mean number of epochs of contact in all bouts (consecutive epochs) of contact.

Latency to contact: Mean number of epochs before contact following a caregiving or medical intervention.

Waking, active sleep, and quiet sleep: Amount of time in each state, measured as a percentage of baby-alone time.

Baby-available time: Amount of baby-available time during each 3-day period of recording.

Total caregiving time: Time spent in caregiving, measured as a percentage of the 3-day period.

Number of caregiving episodes: Number of periods of caregiving during the 3-day period.

Interval between caregiving episodes: Number of epochs between caregiving episodes.

Number of caregiving episodes followed by nurse-initiated contact: Number of episodes of caregiving followed by the nurse placing the baby in contact with the bear.

Results

Three subjects (2 BrBr and 1 N-BrBr) showed virtually no contact during the first 3-day period. This could happen because initial contacts with either bear presumably occurred by chance (the Breathing Bear's breathing is very quiet). Accordingly, these subjects could not be included in the 33-week analysis of contact bout lengths or the repeated measures analysis of contact latency.

Preliminary analyses indicated that there were no sex differences on any measure, and this variable was not included in the final analyses. Preliminary analyses also found that the two groups did not differ significantly at either age with respect to total baby-available time: at 33 weeks, $M = 61.1\%$ ($SE = \pm 5.2$) of the 3-day period for the BrBr group and $M = 55.9\%$ ($SE = \pm 4.1$) for the N-BrBr group; at 35 weeks, $M = 66.7\%$ ($SE = \pm 2.8$) for the BrBr group and $M = 59.2\%$ ($SE = \pm 3.6$) for the N-BrBr group. Therefore, it was appropriate to use contact measures from the two groups on the basis of baby-available time.

Measures of Contact

Table 2 lists, for the two groups at 33 and 35 weeks of age, the means, standard errors, and sample sizes for the four major contact variables: total contact, frequency of contacts, bout lengths, and latency to contact. In addition, for each variable, the Spearman rank-order correlation between 33 and 35 weeks within each group is given.

Three of the four correlations for the BrBr subjects were significant, whereas none of the correlations over age were significant for the N-BrBr subjects. For the three variables, this discrepancy violates the assumption of homogeneity of regression needed to pool the within-error terms for the two groups in order to do a repeated measures analysis of variance (ANOVA). Therefore, the data for total contact, mean bout lengths, and frequencies of contact bouts were analyzed by a correlated t test comparing the change between 33 and 35 weeks within each group separately, and then using uncorrelated t tests to assess the group differences at each age. The latency to contact variable was evaluated by using ANOVA.

Total contact. For the BrBr infants, there was a significant increase in total contact time over the intervention period, $t(22) = 2.32$, $p < .05$, but there was not a significant change for the N-BrBr infants. At 33 weeks, there was not a significant group difference, but at 35 weeks the BrBr infants showed significantly more contact, $t(43) = 5.05$, $p < .01$. These results replicate our previous studies.

Frequency of contact bouts. Although the BrBr infants increased their frequency of contact over the 2-week intervention period and the N-BrBr infants decreased their frequency, there was not a significant change for either group nor a significant group difference at either age.

Mean bout lengths of contact. There was not a significant increase over time in the mean bout lengths for either group. There was not a group difference at 33 weeks, but at 35 weeks, the BrBr infants showed significantly longer bout lengths, $t(40) = 2.29$, $p < .05$. These results suggest that the Breathing Bear became more salient as a reinforcer over the intervention period.

Latency to contact. As indicated in Table 2, there was not a significant correlation over age for either group, so an ANOVA was run for these data. The ANOVA revealed a significant Group × Age interaction, $F(1, 40) = 4.21$, $p < .05$, and separate group comparisons were made at the two ages. At 33 weeks, the two groups did not differ, whereas at 35 weeks, the difference between the groups was significant, $F(1, 40) = 2.51$, $p < .05$. Thus, by 35 weeks CA, the BrBr babies found the bear sooner following a caregiving intervention. These results suggest that the BrBr babies had learned an association between their movements in the direction of the bear and the stimulation provided by the bear.

Relationship Between Change in Amount of Contact and Change in Contact Latency

A learning hypothesis would be further supported if the BrBr infants' increase in total contact over the 2-week period was associated with a decrease in their latency to make contact. A significant correlation was found between the change in these two measures for the BrBr group, $r(19) = -.636$, $p < .01$, whereas this correlation was not significant for the N-BrBr babies. The upper panel of Figure 2 presents the scatterplot of these data for the BrBr group, and the lower panel presents the scatterplot for the N-BrBr group.

Relationship Between Change in Contact Latency and Change in Frequency of Bouts of Contact

A learning hypothesis would also be supported if the changes over age in contact latencies were related to changes over age in

Table 2
Measures of Major Contact Variables: Means, Standard Errors, and Correlations Between 33 and 35 Weeks Conceptional Age (CA)

		33-weeks CA		35-weeks CA		
Variable	Group	*M*	*SE*	*M*	*SE*	*r*
Total contact	BrBr	37.4	4.48	46.2	2.22	.560**
(% available time)	N-BrBr	28.7	2.60	29.4	2.49	.201
Latency to contact	BrBr	8.5	0.60	7.4	0.44	.045
(no. of 5-min epochs)	N-BrBr	8.5	0.52	9.5	0.72	.361
Bout lengths contact	BrBr	8.6	0.88	9.7	0.79	.663***
(no. of 5-min epochs)	N-BrBr	7.0	0.63	7.3	0.70	.239
Frequency of bouts	BrBr	0.6	0.05	0.7	0.05	.415*
(no. of bouts/hr)	N-BrBr	0.7	0.06	0.6	0.06	.305

Note. BrBr = Breathing Bear group; N-BrBr = Nonbreathing Bear group.
* $p < .05$. ** $p < .01$ *** $p < .001$.

the frequencies of contact in the BrBr infants. This correlation was significant for the BrBr group, $r(19) = -.766$, $p < .01$, and was not significant for the N-BrBr babies. The upper panel of Figure 3 presents the scatterplot of these data for the BrBr group, and the lower panel presents the scatterplot for the N-BrBr group. These results suggest that the BrBr babies were learning about finding the bear, even though the total frequency of bouts did not differ for the two groups.

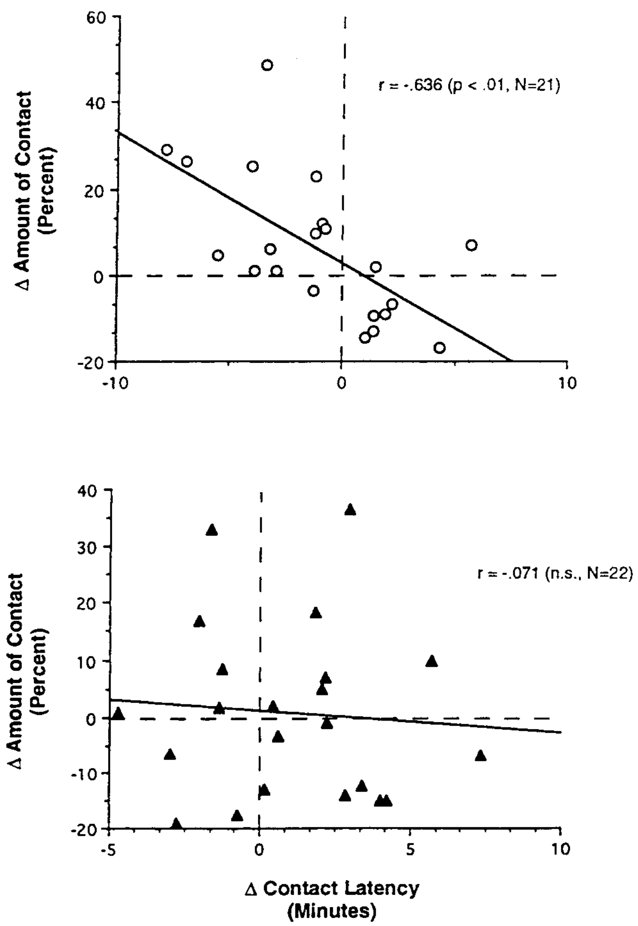

Figure 2. Correlations between measures of change in amount of contact and change in latency to contact. (Upper panel = Breathing Bear group; lower panel = Nonbreathing Bear group.)

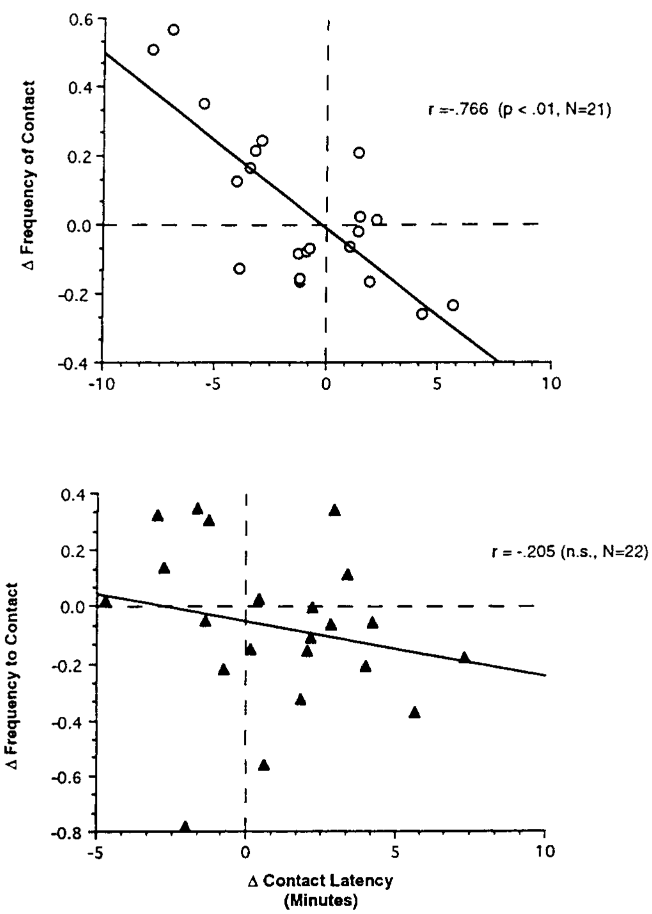

Figure 3. Correlations between measures of change in frequency of contact bouts and change in latency to contact. (Upper panel = Breathing Bear group; lower panel = Nonbreathing Bear group.)

Infants' Responses to Nurse-Initiated Contact

Although the nurses were instructed to place the babies in the middle of the isolette mattress after a caregiving intervention, on occasion a nurse would placed a baby of either group close to his or her bear. Although all contact measures excluded these periods of contact, the infants' responses to such placement events were analyzed. When placed in contact with the bear, the infants could move closer, move away from the bear, or make no change in proximity. Table 3 presents the percentage of time the infants exhibited each of these three responses at 33 and 35 weeks CA. An ANOVA for the distribution of these responses for the two groups indicated a significant Group × Pattern interaction, $F(2, 78) = 3.43$, $p < .05$. There was a significant difference between the groups for the measure of moving closer, $F(1, 39) = 5.51$, $p < .05$, with the BrBr infants moving closer to their bears more often than the N-BrBr infants. These results clearly indicate a greater preference for contact with a Breathing Bear than a Nonbreathing Bear.

Possible Sources of Bias in the Results: Nurse Caregiving

Four caregiving measures were assessed for their possible contribution to the group differences obtained: the mean caregiving time, the mean frequency of caregiving episodes, the mean interval between caregiving episodes, and the percentage of caregiving episodes after which the infant was placed in contact by the nurse. Table 4 presents the means and standard errors for these variables for the two groups at 33 and 35 weeks.

Total caregiving time. The most direct assessment of possible differences in caregiving was in terms of the total caregiving time provided for the infants during the 3-day period at the beginning and the end of the 2-week intervention. There was not a group or a Group × Age effect. There was a significant age effect, $F(1, 43) = 14.753$, $p < .001$, with both groups having increased caregiving time from a mean of 16.0% ($SE = \pm 0.55$) to a mean of 17.9% ($SE = \pm 0.60$) of the 3-day period. Thus, the groups were not differentiated by the nurses in terms of the amount of time spent with the infants at either age.

Frequency of caregiving episodes and mean interval between caregiving episodes. There was not a significant group effect for either of these measures. There was a significant age effect for both, as the frequency of episodes decreased for both groups, $F(1, 43) = 18.16$, $p < .01$, while the intervals between caregiving episodes increased, $F(1, 43) = 9.39$, $p < .01$. There was not a Group × Age interaction for either variable. These results also support the conclusion that the groups were not treated differently by the nursing staff.

Nurse-initiated contact. There was not a significant difference between the groups nor a Group × Age interaction effect for this variable. Thus, it is not relevant as a possible confound for the results obtained from the contact measures. As indicated, these periods of contact were excluded from all contact measures.

Other Possible Sources of Bias in the Results Obtained: Infants' States

To argue for learning as a mediating process for the changes observed in the infants' contact responses to the Breathing Bear, we precluded the possibility that the intervention (the presence of the Breathing Bear) induced a change in the infants' states that could be related to their achieving or maintaining contact with the bear.

Infants' states following caregiving. Table 5 presents the percentage of all caregiving episodes followed by each of the states —waking, active sleep, and quiet sleep—at 33 and 35 weeks. An ANOVA using states as repeated measures revealed no group or interaction effects. Thus, the groups did not differ with respect to their states following caregiving.

Overall state patterns at the two ages. Table 6 presents the percentage of baby-available time spent in each state, for the BrBr and N-BrBr groups at 33 and 35 weeks. An ANOVA indicated no group difference and no Group × Age interaction. There was a significant State × Age interaction, $F(2, 86) = 22.50$, $p < .001$. This effect reflected a significant decrease in the amount of waking over the 2 weeks, but the groups did not differ. Thus, the distribution of the infants' states did not account for the increased contact, longer contact bouts, or shorter latencies to achieve contact by the BrBr babies.

Wakefulness and the infants' responsiveness to the bear. Because wakefulness is a state with high motor activity, this state was explored further. The correlations between the amount of wakefulness and each of the contact measures were calculated separately for the two groups. Waking was negatively correlated with contact latency for the BrBr babies during the first 3 days of the intervention period, $r(19) = -.63$, $p < .05$, but

Table 3
Mean Percentages and Standard Errors of Nurse-Initiated Contacts Followed by Infants' Moving Closer to the Bear, Moving Away, or Making No Change

	33-weeks CA			35-weeks CA		
Group	Closer	Away	No change	Closer	Away	No change
Breathing Bear						
M	53.6	17.9	28.7	54.8	15.7	29.5
SE	11.99	3.99	6.41	11.42	3.28	6.15
Nonbreathing Bear						
M	48.1	18.8	33.2	40.5	26.5	32.8
SE	10.24	4.00	7.07	8.84	5.79	7.16

Note. CA = conceptional age.

Table 4
Measures of Nurses' Caregiving Practices at 33 and 35 Weeks Conceptional Age (CA): Mean and Standard Errors

Variable	Group	33-weeks CA *M*	33-weeks CA *SE*	35-weeks CA *M*	35-weeks CA *SE*
Total caregiving time (% total time)	BrBr	15.5	0.81	17.4	0.88
	N-BrBr	16.5	0.76	18.4	0.81
No. of caregiving episodes	BrBr	49.1	2.02	45.5	1.93
	N-BrBr	53.7	2.85	46.8	2.31
Mean interval between episodes (no. of 5-min epochs)	BrBr	15.4	0.58	16.5	0.63
	N-BrBr	14.5	0.76	15.9	0.64
% of caregiving episodes, contact nurse-initiated	BrBr	40.0	4.33	42.8	4.71
	N-BrBr	31.8	4.63	38.8	4.43

Note. BrBr = Breathing Bear group; N-BrBr = Nonbreathing Bear group.

there was not a significant relationship for either group at 35 weeks.

Discussion

The results of this study confirm the inference that stimulation from the Breathing Bear is reinforcing, and they indicate that prematures are capable of making directional movements to locate such a reinforcing source of stimulation. From the evidence presented, it is reasonable to infer that the change over time in the infants' approach and contact with the bear was mediated by learning.

The BrBr infants showed a decreased latency to contact the bear over the 2-week intervention period, while they showed an increased amount of contact. Furthermore, those BrBr babies who showed a greater increase in contact were the ones who showed a greater decrease in latencies and a greater increase in frequencies of contact. There were no relationships between changes in contact with changes in latencies or frequencies of contact for the N-BrBr babies. Thus, it appears that increased overall contact in the BrBr group occurred because these babies were finding the bear sooner after a caregiving intervention, and they were finding the bear more often.

A number of potential sources of confounds from differences in nursing activities were examined because it was obvious to the nursing staff which bears were breathing. We found no differences between the groups in the amount of caregiving, the frequency of caregiving episodes, or the mean time between caregiving episodes. In addition, the nurses did not place infants in contact with Breathing Bears more than with Nonbreathing Bears (nevertheless, contact episodes following nurse caregiving were not included in any of the contact measures). Thus, there is no evidence that the nurses treated the two groups differently.

Although the nurses did not put the babies in contact with their bears more often in one group, the babies' reactions when they were put down in contact with the bear differed. Under these circumstances, the babies could maintain the same proximity to the bear until another occurrence of caregiving, they could move closer to the bear, or they could move away from the bear. We found that the BrBr babies were more likely to move closer to their bear. This finding further highlights the responsiveness of the babies to a Breathing Bear and, thus, the reinforcing properties of the bear.

Another question that was addressed was whether the babies' responsiveness to the Breathing Bear was, at least in part, a function of group differences in their sleep/wake states. However, there was not a group difference in overall distribution of their states, and there were no differences in the distribution of the states the babies showed following caregiving.

Because the highest levels of motor activity occur during waking, and motor activity is necessary for the babies to move to the bear, wakefulness should be the likely candidate for differentiating the groups. A distinction between active and quiet wakefulness was not made in this study because quiet wakefulness occurs so rarely at this early age (about 7% of wakefulness is quiet wakefulness; Holditch-Davis, 1990; Korner, Lane, Berry, Rho, & Brown, 1990). Both groups showed a decrease in wakefulness over the 2-week intervention period. Because contact increased for the BrBr babies and did not change for the N-BrBr babies over the 2-week intervention period, it is reasonable to conclude that wakefulness did not play a role in this change. Rather, the BrBr babies learned to use their movements more effectively to achieve greater contact with the Breathing Bear.

Until our studies with the Breathing Bear, the motor activity of premature infants has been described as random activity

Table 5
Mean Percentages and Standard Errors of Caregiving Episodes Followed by Quiet Sleep, Active Sleep, and Waking for the 3-Day Period at Each Age

Group	33-weeks CA Quiet sleep	33-weeks CA Active sleep	33-weeks CA Waking	35-weeks CA Quiet sleep	35-weeks CA Active sleep	35-weeks CA Waking
Breathing Bear						
M	4.3	38.4	57.3	9.2	44.0	46.9
SE	0.94	2.56	2.47	1.61	2.72	3.14
Nonbreathing Bear						
M	6.9	38.7	54.4	10.7	39.4	49.9
SE	1.11	2.30	2.83	1.55	2.80	3.28

Note. CA = conceptional age.

Table 6
Mean Percentage of Time and Standard Error Spent in Quiet Sleep, Active Sleep, and Waking for the 3-Day Period at Each Age

	33-weeks CA			35-weeks CA		
Group	Quiet sleep	Active sleep	Waking	Quiet sleep	Active sleep	Waking
Breathing Bear						
M	10.1	55.9	34.1	14.7	58.2	27.1
SE	0.83	1.24	1.64	1.07	1.55	1.47
Nonbreathing Bear						
M	11.0	56.9	32.2	17.4	57.2	25.4
SE	0.93	1.18	1.55	1.69	1.50	2.16

Note. CA = conceptional age.

because of its disorganized appearance. Our findings indicate that prematures are able to organize their movements sufficiently to achieve physical proximity and contact with a reinforcing stimulus object.

It is important to note that these changes by the BrBr babies occurred in the absence of an auditory cue from the bear, which was designed to breathe quietly.

Although learning in the fetus and newborn rat has been studied (e.g., Smotherman & Robinson, 1985; Thoman, Wetzel, & Levine, 1968), the premature infant has been a neglected subject for learning studies. The Breathing Bear provides a nonintrusive and apparently ecologically appropriate condition for exposing the premature infant's competence in mobilizing motor behavior to accomplish an approach to a stimulus object. As a learning paradigm, these conditions permit the baby to learn, over a 2-week period, that an approach response is rewarded by contact with an object that provides rhythmic stimulation reflecting the baby's own breathing rhythm.

Benefits of the experience with the Breathing Bear have been demonstrated in previous studies, in terms of facilitation of neurobehavioral development expressed in increased quiet sleep during the preterm period (Thoman & Graham, 1986) and during the early postterm weeks (Thoman et al., 1991). The findings of this study suggest that these effects on the developing nervous system are the consequence not only of the individualized rhythmic stimulation that the babies receive from the Breathing Bear but are also a function of the instrumental learning acquired at such a very early age.

It is reasonable to speculate that there may be other, less obvious, benefits of the Breathing Bear as an early learning experience. Rovee-Collier (1987) noted that "extensive exposure to noncontingent stimulation early in infancy can result in future maladaptive behavior ranging from retarded learning . . . to failure to thrive and clinical depression" (p. 123). Considering the barrage of noncontingent stimulation to which the premature infant is constantly exposed in the nursery, the Breathing Bear, as a positive learning experience, may serve to ameliorate some of the debilitating effects of the unavoidable negative associations involved in medical care of prematures. That is, it is reasonable to speculate that later development may be facilitated by experience with an attractive (approach-eliciting) "companion" that provides an opportunity for the preterm infant to acquire control over one aspect of the environment. This possibility is currently being investigated.

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